1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/5/15	Edward O'Brien

4. WBS Element Code	5. WBS Element Title
1.01	Project Management of sPHENIX

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost covering the Project Management team. Material costs for travel of the Management team over the life of the project. Additional material costs associated with preparation for DOE and BNL reviews.

TECHNICAL SCOPE:

This task includes all scientific, engineering, technical and support staff efforts to plan and supervise all aspects of the assembly, integration and installation of the sPHENIX defined in WBS 1.2 through WBS 1.10.

Effort required by Project Management team of Project Coordinator, Project Manager-Science, Project Manager-Engineering, Chief Engineer and Project Controls to oversee all management aspects of the sPHENIX project from CD-1 approval to CD-4 sign-off.

WORK STATEMENT:

Tasks to be performed by the Project Management team include:

1) The oversight and management of the design, construction, installation and commissioning of sPHENIX .

2) Preparation for DOE and BNL reviews including CD reviews by OPA, DOE annual review, safety reviews, readiness reviews, etc.

3)Preparation and submission of all reports and documentation required by DOE and BNL including Conceptual and technical design reports, Earned Value reports, ES&H plans, procurement plans, etc.

4) Monitoring the activities of all WBS tasks through the Level2 managers to assure assure adherence to the technical, budget and schedule plan of the sPHENIX project.

5)Work with the Level2 managers to monitor all vendor activity to assure compliance with technical, budget and schedule specs.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Phillips

4. WBS Element Code	5. WBS Element Title
1.02	sPHENIX Decommissioning

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description
COST CONTENT: Summary Item - Rolls up costs from WBS Items 1.02.01 and 1.02.02 TECHNICAL CONTENT: Includes project management and oversight of decommissioning efforts, preparation for decommissioning, disassembly and disposition of the existing PHENIX detector to make the PHENIX 1008 complex ready to accommodate the sPHENIX detector. WORK STATEMENT: See Subtasks

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	P. Giannotti

4. WBS Element Code	5. WBS Element Title
1.02.01	Decommissioning Preparation and Oversight

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor for project management of decommissioning based on Subsystem scientist with 25% of time and subsystem engineer 50% time spent on project management of this task. For all other tasks Labor and material costs are estimated based on similar projects and activities at CAD. The costs in this section are for materials and contract labor costs incurred prior to the actual decommissioning effort. (e.g. lifting fixtures, specialized tools, storage facility shelves, etc.)

TECHNICAL CONTENT:

This task includes all scientific, engineering and technical staff efforts to plan, implement and supervise all aspects of the design, procurement, construction, assembly, testing and review of procedures, equipment associated with decommissioning of PHENIX, and identification and preparation of storage facilities for proposed disposition of PHENIX components which will be retained for future use.

WORK STATEMENT:

The tasks associated with this effort are as follows:

Subsystem Project Management - Liaison Physicist and Liaison Engineer
Deliverables: none

Decommissioning Plan - Sum of all conceptual efforts to prepare for the decommissioning of PHENIX.
Deliverables: written plans

Lifting Fixture identification/design - For each subsystem to be decommissioned the plan is analyzed and the need for lifting fixtures is identified and appropriate design documentation is prepared. In some cases no fixtures will be needed, in some cases the fixtures exist and can be used as is, in other cases existing fixtures will be need to be modified.

Deliverables: fabricated/identified lifting fixtures as required by the plan. (estimate 3 new lifting fixtures and 10 existing fixtures)

Lifting Fixture certification - Certification tests for each identified new lifting fixture or modified existing fixture, or re-certification for existing fixtures not requiring modification.

Deliverables: Certified lifting fixtures as required by the plan. (estimate 3 new lifting fixtures and 10 existing fixtures)

Storage area identification - For each subsystem to be decommissioned for which a storage area will be needed (i.e. decommissioned equipment to be retained for future disposition.) analyze the area needed and identify the area to be so utilized. Areas for storage will be needed for racks, Rich East & West, EMCal modules, beampipe sections, MPC's, MPC-Ex's, Aerogel, FVTX/VTX, BBC's, RPC1's,

Deliverables: Available storage space Identified -MOU for use of these spaces.

Storage area prep - For each storage area identified, determine the effort and materials (e.g. storage shelves) needed to serve the subsystem associated with that area.

Deliverables: Work plan/permit for each space identified, equipment identified and procured

Work Permits and Procedures -
Effort required to develop detailed work procedures, work permits and related documentation including review and approval.

Deliverables: Approved work plans/permits for all decommissioning tasks (estimate 10 WP's)

Design and Safety Reviews - As determined by the decommissioning plan to assure the efficient, effective and safe accomplishment of the decommissioning effort.

Deliverables: Completion of all review action items

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	P. Giannotti

4. WBS Element Code	5. WBS Element Title
1.02.02	Disassembly and Disposition of the PHENIX Detector

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor, contracted labor and material costs for all efforts to remove PHENIX detector components as necessary to make way for sPHENIX upgrade. Includes all efforts after the end of run 16 until the IR is ready to begin sPHENIX installation.

TECHNICAL CONTENT:

All efforts to remove PHENIX detector components as necessary to make way for sPHENIX upgrade. Includes all efforts after the end of run 16 until the IR is ready to begin sPHENIX installation. Includes disposition (discard or store for future use) of all relevant PHENIX subsystems.

WORK STATEMENT:

The tasks required to decommission PHENIX are defined as follows:

Initial Tasks to prep for Decommissioning after run 16:

> This include all of the tasks normally undertaken at the start of each shutdown period between PHENIX runs to open the IR and separate the carriages to allow work on the various subsystems. Tasks include shield wall removal, MuID collar removal, Gas purge, Carriage preparation, disconnects and moves

Dismantle EC:

This includes all of the effort required to remove all of the subsystems, support components and services from the EC and to dismantle and the EC itself, plus disposition of all of components. Subsystems and components include racks, Drift Chamber, Rich, TOF East, PC1 east, PC3 east, TEC, PbGl, PbSc, and EMCal. Racks, Rich PMT's, EMCal modules are to be preserved for future use. All else is to be discarded/scrapped.

Remove and Preserve Beampipe:

This includes all of the effort required to remove all of the beampipe sections and support components, plus disposition of all of components. All beampipe components are to be preserved for sPHENIX use.

Dismantle MMS:

This includes all of the effort required to remove all of the subsystems and support components from the MMS and to dismantle and the MMS itself, plus disposition of all of components. Subsystems and components include racks, MPC South, MPC-Ex south, MuTr and Muon Trigger stations 1, 2 and 3 south, "eyebrow" platform and Muon Trigger platform. Racks, MPC , MPC-Ex and platforms are to be preserved for future use. All else is to be discarded/scrapped.

Dismantle WC:

This includes all of the effort required to remove all of the subsystems and support components from the WC and to dismantle and the WC itself, plus disposition of all of components. Subsystems and components include racks, Drift Chamber, Rich, TOF west, PC1, PC2 and PC3 west, PC3 west, PbSc, and EMCal. Racks, Rich PMT's, EMCal modules are to be preserved for future use. All else is to be discarded/scrapped.

Dismantle CM:

This includes all of the effort required to remove all of the subsystems and support components from the CM and to dismantle and the CM itself, plus disposition of all of components. Subsystems and components include racks, BBC's, RPC1's, FVTX/VTX, and upper rack platform which are all to be preserved for future use. All else is to be discarded/scrapped.

Dismantle MMN:

This includes all of the effort required to remove all of the subsystems and

support components from the MMN and to dismantle and the MMN itself, plus disposition of all of components. Subsystems and components include racks, MPC north, MPC-Ex north, MuTr and Muon Trigger stations 1, 2 and 3 north, MMS upper platform and Muon Trigger platform. Racks, MPC , MPC-Ex and platforms are to be preserved for future use. All else is to be discarded/scrapped.

IR Support Structures and Non-IR decommissioning:

This includes all of the effort required to remove all of the subsystems and support components not on the major carriages in the IR, and other PHENIX subsystems not in the IR requiring decommissioning, plus the disposition of all these components. Unless otherwise determined during detailed planning stages all non-IR infrastructure shall be decommissioned in place. sPHENIX may use much of this, but if not (e.g. gas piping and equipment used in PHENIX but not needed for sPHENIX), this equipment structures etc. appropriately cleaned, capped, covered or otherwise prepared for storage in place until needed in the future.

SPHENIX	02/17/2015	K. Yip

4. WBS Element Code	5. WBS Element Title	
1.03.01 Magnet Management	Magnet Project Management	
6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description
COST CONTENT: TECHNICAL SCOPE: WORK STATEMENT:

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/17/2015	M. Anerella

4. WBS Element Code	5. WBS Element Title	
1.03.02.01 Magnet Mechanical Coil/Core Modifications	Engineering and Design	
6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description
COST CONTENT: All costs in this Item are labor based, no material costs. All labor costs are based on engineering estimates for engineering and other technical professionals contributions to the design and documentation associated with the technical items listed below. TECHNICAL SCOPE: This item includes all tasks required to specify and design the following sPHENIX infrastructure items: Mechanical support structures (those structural components of the sPHENIX detector which integrate and structurally support the detector subsystem that comprise the magnet support mounting and associated alignment features). WORK STATEMENT: The efforts required to complete this WBS item are described for the various subtasks as follows: Mechanical Support Structures Design - This task encompasses design of structural alignment and support for the sPHENIX magnet within the calorimeter. Deliverables: drawings: estimated 1 assembly, 20 detail drawings.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/30/2015	R. Than

4. WBS Element Code	5. WBS Element Title
1.03.02.02 Cryogenics System	Engineering & Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on Subsystem engineer (s) , engineering manager and designer(s) time spent on engineering and design for this task.

TECHNICAL SCOPE:

Level 1 and level 2 engineer(s) and designer(s) labor spent on engineering, design, overseeing and managing of these engineering and design activities for the cryogenic equipment and its subsystems to be procured. Includes design documents and drawings, specification and statements of work (SOW's), engineering analyses, presentations, reports, budgeting, etc.

WORK STATEMENT:

Engineering and design

Task . 01. RHIC lines S/R/H/U-Line Taps & valvebox Engineering & Design and

Task . 02. Helium Transfer Line Bundle System Engineering & Design

Process design, pipe stress analysis, and relief devices calculations for piping interface tie-ins to RHIC cryo lines from the isolation valvebox. Equipment Specifications and SOW development. General arrangement layout and overall detail piping dwgs for interface piping tie-ins to RHIC cryolines and envelope and scope layout drawing for valvebox. Develop schedule.

Deliverables:

Procurement package for Valvebox and Helium Transfer Line Bundle.

a. Process design and engineering documents
b. P&ID diagram(s)
c. Drawings package for Valvebox and Helium Transfer Line Bundle.
d. SOW and Technical Specifications documents

Engineering and Drawings packages for the interface tie-ins to RHIC cryolines

e. Pipe stress analyses
f. Relief calculations
g. Drawings package with weld map and BOM
h. LESHC review package

Task . 03. Warm Piping/Relief/Vent System Engineering & Design

Process design, pipe stress analysis and supports, and relief devices calculations for piping.

Deliverables:

Procurement package for Warm/Relief/Vent piping systems

i. Process design and engineering documents
j. P&ID diagram(s)
k. Drawings package for
l. SOW and Technical Specifications documents

Task . 04. LN2 Cooling System for summer shutdown Engineering & Design

Process design, engineering and design for this subsystem. Equipment Specifications and SOW development. General arrangement layout and overall dwgs for equipment envelopes and scope layout drawing for this susbsystem. Develop schedule.

Deliverables:

2. Procurement package for LN2 Cooling System for summer shutdown.
    a. Process design and engineering documents
    b. P&ID diagram(s)
    c. Drawings package for subsystem envelope and piping routing
    d. SOW and Technical Specifications documents

Task . 05. Cold-box with Heat-exchangers, Solenoid Valve-box upgrade and 500L Reservoir: Engineering & Design

Process design, engineering analysis, and relief devices calculations for Cold-box with Heat-exchangers, Solenoid Valve-box upgrade and 500L Reservoir with interconnect cryo lines jumpers.

Deliverables:

Procurement package for Cold-box with Heat-exchangers, Solenoid Valve-box upgrade and 500L Reservoir

a. Process design and engineering documents
b. P&ID diagram(s)

c. Drawings package for subsystem envelope and piping routing
d. SOW and Technical Specifications documents

Task . 06. CryoControls: Hardware Engineering & Design

Controls and instrumentation engineering and design. Define hardware requirements for the cryo controls system.

Deliverables:

a. Instrument list specification document
b. PLC and chassis and I/O list specification document
c. Wiring diagrams: I/O chassis/Rack terminals/cable/junction box/instruments
d. 120VAC, 208VAC, 480VAC Electrical Interface Specifications documents
e. Rack build drawings

Task . 07. CryoControls: Software Engineering & Design

Process engineer to define control logic and interface requirements for the equipment.

Define instrument and control valves, heaters, motor control center lists. Type, range, units, alarms, and interlocks.

Deliverables:

a. Control logic specification document, Process Engineering
b. Operator screen specification document

Task . 08. Operations: Operating Procedures and interfaces Specification documents Engineering & Design

Interface specification documents for utilities: Cooling Water, instrument air, HVAC and control racks space, cryo controls junction panels and electrical control panel, MCC wall space.

Deliverables:

a. Operating procedures list for the OPM/SOP to be written during fabrication period
b. Interface specification documents for utilities and building

infrastructure (ladders, platforms, piping supports).

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/09/2015	R. Lambiase

4. WBS Element Code	5. WBS Element Title
1.03.02.03 Magnet Power Supply & Quench Protection	Engineering and Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on engineering estimates.

TECHNICAL SCOPE:

The scope includes examining existing equipment and designing modifications and new equipment. This WBS will define procurement requirements for the next WBS.

WORK STATEMENT:

1. Evaluation of existing equipment: The power supply will be tested without modification to establish a baseline of functionality and performance. The quench switch and energy dump resistor will be examined to determine what refurbishment is required.

2. Power supply upgrade design:
    a. The existing PLC and its software will be replaced with a more modern model, which is in general usage at BNL.
    b. Controls interface: The existing SLAC controls interface will be replaced by a standard BNL power supply interface (PSI).
    c. A new card to control the triggers to the SCRs will be installed to improve performance.

3. Quench detector design:
    a. A new, modern, quench detector will be designed.
    b. Interfaces between the power supply, quench detector, and energy dump resistor will be defined.
    c. Communication between the quench detector and the BNL accelerator controls will be designed.

4. Interface design:
    a. AC power to the power supply
    b. DC high power (water cooled bus) from PS to magnet
    c. Signal cables and fibers for controls and interlocks.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/04/2015	A. Franz

4. WBS Element Code	5. WBS Element Title
1.03.02.04 Magnet Field Measurements	Engineering and Design, Field Studies and Stress Analysis

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

All costs in this Item are labor based, no material costs. All labor costs are based on engineering estimates for scientific, engineering and other technical professionals' contributions to the design and documentation associated with the technical items listed below.

TECHNICAL SCOPE:

Level 2 engineer & scientist overseeing and managing simulations and design.

WORK STATEMENT:

Manage and guide the scientific and engineering management of sPHENIX magnet simulation and field measurement and monitor tasks, including:

1. Setting up a detailed 3D model of the solenoid, the external calorimeter which serves as the return yoke, and the non-magnetic internal calorimeters. Perform a field calculation and analyze the stresses on the calorimeter plates and solenoid coils.

2. Supervising and managing the design and precision mounting of a support for the CERN field mapper on the magnet.

3. Supervising and managing the design and production of precision mounts and readout system for NMR probes inside the solenoid for monitoring the field during operation.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/17/2015	M. Anerella

4. WBS Element Code	5. WBS Element Title
1.03.03.01 Magnet Mechanical Coil/Core Modifications	Fabrication

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

The costs associated with this item are for both labor and materials. The labor is the effort by engineers associated with the procurement of material and equipment described in the infrastructure design WBS dictionary entry. All labor and material estimates for this are based on engineering estimates.

TECHNICAL SCOPE:

This item includes all tasks required to procure material and equipment for the following sPHENIX infrastructure items

Mechanical support structures (those structural components of the sPHENIX detector which integrate and structurally support the detector subsystem that comprise the magnet support mounting and associated alignment features).

WORK STATEMENT:

The efforts required to complete this WBS item are described for the various subtasks as follows:

Mechanical Support Structures Procurement - This task encompasses fabrication and procurement of structural alignment and support for the sPHENIX magnet within the calorimeter.

Deliverables: Magnet mounting and alignment provisions.

Note: (Assembly and installation of the above infrastructure components is not included in these estimates.)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/30/2015	R. Than

4. WBS Element Code	5. WBS Element Title
1.03.03.02 Cryogenics System	Fabrication

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Costs in this Item are material costs and labor cost to support procurements and project engineering during fabrication phase. All labor costs are based on engineering estimates for scientific, engineering and other technical professionals contributions to the design and documentation associated with the technical items listed below. Material cost are based on engineering judgment, previous purchased equipment,

TECHNICAL SCOPE:

This item includes all tasks required to procure the major cryogenic equipment, program the controls system and operator interface, build the control racks, and write operating procedures, and prepare for Laboratory safety and Technical Reviews:

WORK STATEMENT:

The efforts required to complete this WBS item are described for the various subtasks as follows:

Task . 01. RHIC lines S/R/H/U-Line Taps & valvebox Fabrication

Task . 02. Helium Transfer Line Bundle System Fabrication

Execute RPQ/RFP, and procurement of these subsystems. Manage and interface with vendors during the procurement cycle, update schedule based on procurement progress. Prepare and hold review with Laboratory's LESHC-PSSC safety review.

Task . 03. Warm Piping/Relief/Vent System Fabrication

Execute RPQ/RFP, and procurement of these subsystems. Manage and interface with vendors during the procurement cycle, update schedule based on

procurement progress. If issued to outside contractor, installation will occur during installation phase.

Task . 04. LN2 Cooling System for summer shutdown Fabrication

Execute RPQ/RFP, and procurement of these subsystems. Manage and interface with vendors during the procurement cycle, update schedule based on procurement progress. If issued to outside contractor, installation will occur during installation phase. . Prepare and hold review with Laboratory's LESHC-PSSC safety review.

Task . 05. Cold-box with Heat-exchangers, Solenoid Valve-box upgrade and 500L Reservoir Fabrication

Execute RPQ/RFP, and procurement of these subsystems. Manage and interface with vendors during the procurement cycle, update schedule based on procurement progress. If issued to outside contractor, installation will occur during installation phase. . Prepare and hold review with Laboratory's LESHC-PSSC safety review.

Task . 06. CryoControls: Hardware Fabrication

Procure instruments and controllers/conditioners, PLC and PLC chassis hardware, power supplies, racks and rack components, multi-conductor cables, Heater controls panels, junction box panels.

Task . 07. CryoControls: Software Fabrication

Programming of PLC systems, signals conditioners, and remote I/Os.

Human Machine Interface operator interface screen builds and SCADA database builds.

Task . 08. Operations: Operating Procedures and interfaces Specification documents Fabrication phase

Write Operating procedures for overall system and subsystems.

Project engineering and interfacing between infrastructure group to execute manufacturing and preparation for utilities and other building infrastructure.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/09/2015	R. Lambiase

4. WBS Element Code	5. WBS Element Title
1..03.03.03 Magnet Power Supply & Quench Protection	Fabrication

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

The costs associated with this item are for both labor and materials. The labor is the effort by scientists, engineers, designers, technical staff and BNL trades associated with the procurement of material and equipment described in the Magnet WBS dictionary entry. All labor and material estimates for this are based on engineering estimates.

TECHNICAL SCOPE:

The scope includes procuring most of the materials required and integrating them into the individual subsystems.

WORK STATEMENT:

1. Power supply procurement and fabrication:
    a. A new PLC will be procured, programmed, and wired into the power supply.
    b. A standard PSI, PSC (power supply controller), and fibers will be procured. These will be integrated into the power supply.
    c. A new firing card will be procured and wired into the power supply.
    d. The power supply will be tested as a unit to ensure performance.

2. Quench detector design:
    a. Quench detection equipment will be purchased, programmed, and tested as a unit.
    b. Interfaces between the power supply, quench detector, and energy dump resistor will be tested

3. Interface design:
    a. AC cables and switch gear will be procured.

b. DC high power (water cooled bus) will be procured.
Signal cables and fibers for controls and interlocks will be procured.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/04/2015	A. Franz

4. WBS Element Code	5. WBS Element Title
1.03.03.04 Magnet Field Measurements	Equipment Purchase and Fabrication

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

The costs associated with this item are for both labor and materials. The labor is the effort by scientists, engineers, designers, technical staff and BNL trades associated with the procurement of material and equipment described in the infrastructure design WBS dictionary entry. All labor and material estimates for this are based on engineering estimates.

TECHNICAL SCOPE:

Level 2 engineer, scientist and technical staff overseeing the procurement, design and installation of the field mapping and monitoring equipment.

WORK STATEMENT:

This item includes all tasks required to specify and design the parts for the magnetic field measurement and monitoring:

a. Installation and alignment of the mechanical support structures for the CERN magnetic field mapper which has to be transported from CERN to BNL and precision mounted in the magnet.
b. Procurement of fixed NMR probes and the necessary parts for the readout system for monitoring the field during mapping and operation and their mounting and fabrication.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/17/2015	M. Anerella

4. WBS Element Code	5. WBS Element Title
1.03.04.01 Magnet Mechanical Coil/Core Modifications	Installation/Testing

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

The costs associated with this item are for both labor and materials. The labor is the effort by engineers, technicians and other personnel associated with the preparation of the magnet and valve box for shipment from Building 912 to the experimental hall, and installation, reassembly and alignment of the magnet as described in the infrastructure design WBS dictionary entry. Material costs are for consumables used in the installation and alignment of the magnet. All labor and material estimates for this are based on engineering estimates.

TECHNICAL SCOPE:

This item includes all tasks required for disassembly of the valve box from the magnet, preparation of the magnet and valve box for shipment from Building 912 to the experimental hall, and installation, reassembly and alignment of the magnet as described in the infrastructure design WBS dictionary entry.

Mechanical support structures (those structural components of the sPHENIX detector which integrate and structurally support the detector subsystem that comprise the magnet support mounting and associated alignment features).

WORK STATEMENT:

The efforts required to complete this WBS item are described for the various subtasks as follows:

Magnet System Installation and Alignment - This task encompasses disassembly of the valve box from the magnet in Building 912, preparation of magnet and valve box for transport to the experimental hall, reassembly of the valve box to the magnet in the experimental hall, in situ adjustments and inspections of the magnet and alignment of the magnet to the calorimeter.

Deliverable: Magnet installed and aligned to calorimeter, ready to be powered after upper calorimeter installation.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/30/2015	R. Than

4. WBS Element Code		5. WBS Element Title	
1.03.04.02 Cryogenics System		Installation/Testing	
6. Index Line Number:	7. Revision Number and Authorization:		8: Rev. Date
9. Approved Changes			

9. Element Task Description

COST CONTENT:

The costs associated with this item are for both labor and materials.

The labor is the effort by scientists, engineers, designers, technical staff and BNL or contractor trades associated with the installation and commissioning.

All labor and material estimates for this are based on engineering estimates.

TECHNICAL SCOPE:

Installation of the cryogenics equipment and wiring of the instrumentation and control system.

System check out and Commissioning of system and cooldown of the solenoid.

WORK STATEMENT:

The efforts required to complete this WBS item are described for the various subtasks as follows:

Task . 01. RHIC lines S/R/H/U-Line Taps & valvebox Installation

Rig into location valvebox. Tee into RHIC cryogenic lines and interface to valvebox. Complete vacuum jacket field joints. Welding and leak checking.

Task . 02. Helium Transfer Line Bundle System Installation

Rig into location transfer line bundle and weld field joints. Leak check and close up vacuum jackets.

Task . 03. Warm Piping/Relief/Vent System Installation

Install warm piping and relief and vent lines. Welding and leak checking and pressure testing.

Task . 04. LN2 Cooling System for summer shutdown Installation

Rig into location transfer lines bayonetted segments. Pressure test and Leak check.

Install warm circulator and electric and utilities for this.

Task . 05. Cold-box with Heat-exchangers, Solenoid Valve-box upgrade and 500L Reservoir Installation

Rig into location dewar and coldbox and weld field joints. Leak check and close up vacuum jackets. Pressure test entire piping systems.

Task . 06. CryoControls: Hardware Installation

Pull/set cables through/on cable trays. Wire up instrumentations/valves on all cryo equipment and junction boses, and complete check out. Finish wiring at racks located in service building.

Task . 07. CryoControls: Software

Complete I/O live check out after wiring completion.

Test control logic and actuate valves “live”.

Task . 08. Operations: Operating Procedures complete

System check out and Commissioning of cryogenic system and cooldown of the solenoid.

Ramp up of solenoid to full field.

Task . 09. Laboratory Safety Reviews Phase: Final review meeting and Walkthroughs and Inspections

Hold final review with Laboratory committee and walkthrough after installation.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/09/2015	R. Lambiase

4. WBS Element Code	5. WBS Element Title	
1.03.04.03 Magnet Power Supply & Quench Protection	Installation/Testing	
6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date
9. Approved Changes		

9. Element Task Description

COST CONTENT:

The costs associated with this item are for mostly labor, with a small amount of materials. The labor is the effort by scientists, engineers, designers, technical staff and BNL trades associated with the procurement of material and equipment described in the Magnet WBS dictionary entry. All labor and material estimates for this are based on engineering estimates.

TECHNICAL SCOPE:

The scope includes installing the power supply and quench protection equipment at sPhenix with all controls and power connections.

WORK STATEMENT:

1. Installation of subsystems:
    a. Physical rigging and installation of the power supply, quench detection chassis, energy dump resistor, and the electromagnetic DC contactor.
    b. Electrical interconnection between the subsystems as well as to the accelerator controls.

2. Power installation:
    a. AC power and switchgear to power supply
    b. DC power water cooled bus between subsystems and the magnet.

3. Full system test: Testing as a complete system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	02/04/2015	A. Franz

4. WBS Element Code	5. WBS Element Title
1.03.04.04 Magnet Field Measurements	Installation and Test, Post-Test Field Studies and Stress Analysis

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

All costs in this Item are labor based, no material costs. All labor costs are based on engineering estimates for scientific, engineering and other technical professionals' contributions to the design and documentation associated with the technical items listed below.

TECHNICAL SCOPE:

Level 2 engineer, scientist and technical staff overseeing the installation, operation and removal of the field mapping and monitoring equipment.

WORK STATEMENT:

This item includes all tasks required to perform the field simulations, measurement as well as the installation and testing of the minoring probes

a. perform the magnetic field simulations, field mapping and compare the two datasets .

b. remove and return the mapper to CERN.

c. calibrate and install NMR probes for field monitoring.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	Itaru Nakagawa

4. WBS Element Code	5. WBS Element Title
1.04.01	Tracker Management

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. The management team for the Tracker subsystem is a scientist, engineer and admin each spending a fraction of their time supervising the subsystem for the project's duration.

TECHNICAL SCOPE:

Level 2 manager oversees and manages the design, prototyping, production and testing of the Tracker. Responsibilities include budgeting, preparation of reports and presentations.

WORK STATEMENT:

Provide management and oversight of the design, prototyping, production and testing of the Tracker. Specific tasks include:

1. Work with sPHENIX Project Management team to create and monitor overall budget and schedule for all aspects of the design, prototyping and production of the sPHENIX Tracker.
2. Provide overall management of procurement activities and monitoring of expenditures for the sPHENIX Tracker.
3. Work with scientific and engineering staff to produce all technical design documents. Review documentation to make sure that the design will achieve the performance needed to meet the scientific goals of sPHENIX.
4. Participate in project reviews:
    a. Assist with producing review documents.
    b. Make presentations at project reviews when requested.
5. Organize and schedule technical design, prototype performance and production readiness reviews for the Tracker.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.02.01	Inner Tracker Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for the effort of a scientist, engineer, designer and technician to design the two inner pixel layers of the Tracker. No material costs.

TECHNICAL SCOPE:

The scope includes specification of the inner layer configuration, design modifications of existing ladders and bus cables, design of new mechanical support structures, design of assembly fixtures and design of cooling, signal and power interfaces.

WORK STATEMENT:

This task covers the:

1. Specification of the configuration of the two inner pixel layers of the Tracker
2. Design the modifications to the existing PHENIX pixel ladders and bus cables.
3. Design new mechanical support structures for layers 1 and 2
4. Design a mechanical superstructure for the inner layers.
5. Design the interface for the inner/outer layers
6. Design power, cooling and signal interfaces
7. Design fixtures for ladder modification, inner layer assembly and inner layer testing
8. Preparation for design and safety reviews associated with these tasks. Deliverables are the designs described above.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.02.02.01	Tracker Ladder Modification

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are based on work of a combination of scientists, engineers, technicians and students. Material costs covers the cost of mech superstructure for the inner layers, assembly fixtures for layers 1 and 2, inner layer assembly fixtures and miscellaneous costs supporting assembly

TECHNICAL SCOPE:

The scope includes :

Fabrication of fixtures for ladder modification, modification of existing bus cables, fab of 15 layer 1 ladders and 30 layer2 ladders, procurement and assembly of the mechanical superstructure for layers 1, 2, complete assembly of the two layers, assembly of the layers together and then prep for cooling, signal and power interfaces.

WORK STATEMENT:

This task covers :

1. Fab ladder modification fixtures
2. Modify ladders for layer 1 (15 ladders)
3. Modify ladders for layer 2(30 ladders)
4. Fab mech structure for layer 1, 2
5. Procure superstructure for inner layer

6. Test each ladder layers 1, 2
7. Assemble layers 1, 2
8. Prepare power signal and cooling interface layers 1, 2

Deliverables are a completely assembled layers 1 and 2 of the pixel Tracker including fab of all the ladders, mods of bus cables, mech superstructure procurement and assembly and prep of the layers 1 and 2 for power, signal and cooling interfaces. The completely assembled ladders will be ready for testing, calibration and integration after this step.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.02.02.02	Inner Tracker Ladder Testing/Calibration/Integration

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for scientists, technicians and 2 students to test, debug and calibrate the inner tracker pixel layers 1 and 2

No material costs

TECHNICAL SCOPE:

The scope includes testing and debugging 15 layer 1 ladders and 30 layer 2 ladders. Calibration of the layer 1, 2 ladders is also performed

WORK STATEMENT:

Work includes:

1. Test and debug layer 1
2. Test and debug layer 2
3. Calibrate layer 1
4. Calibrate layer 2

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.03.01	Outer Tracker Layer Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for the effort of a scientist, engineer, designer and technician to design the outer five silicon strip layers of the Tracker. No material costs.

TECHNICAL SCOPE:

The scope includes specification of the outer layer configuration, design of the strip ladders and bus cables, design of mechanical support structures, design of assembly fixtures and design of cooling, signal and power interfaces

WORK STATEMENT:

This task covers the:

1. Specification of the configuration of the five outer silicon strip layers of the Tracker
2. Design the ladders and bus cables for the strip layers.
3. Design new mechanical support structures for layers 3-7
4. Design a mechanical superstructure for the outer layers.
5. Design power, cooling and signal interfaces
6. Design fixtures for ladder assembly, inner layer assembly and inner layer testing
7. Preparation for design and safety reviews associated with these tasks. Deliverables are the designs described above.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.03.02.01	Outer Tracker Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is labor from a scientist, engineers, designers and students to design, procure, fabricate, assemble and test the v1 prototype of the Tracker outer layer ladders.

Material costs include costs for the ladder mechanics, silicon strip sensors, bus cable, signal, power and cooling interface and testing fixture

TECHNICAL SCOPE:

Scientists, engineers, designers and students to design and build the v1 prototype for the Tracker. Tasks include design of the sensor, ladder, bus cable and interfaces. Procurement and fab of the v1 prototype are also covered . The v1 prototype ladder will be tested on the bench by scientists, students and techs. The tests will be evaluated in preparation for the next round of prototyping

WORK STATEMENT:

Work covered by this WBS includes:

1. Specify prototype v1
2. Design ladder prototype v1
3. Design sensor prototype v1
4. Design bus cable prototype v1
5. Design power interface prototype v1
6. Design signal interface prototype v1
7. Design cooling interface prototype v1

8. Design review
9. Procure ladder v1
10. Procure bus cable v1
11. Procure sensor v1
12. Procure power, signal and cooling interface, v1
13. Assemble prototype v1
14. Test prototype v1
15. Evaluate the prototype test v1

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.03.02.02	Outer Tracker Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is labor from a scientist, engineers, designers and students to design, procure, fabricate, assemble and test the v2 prototype of the Tracker outer layer ladders.

Material costs include costs for the ladder mechanics, silicon strip sensors, bus cable, signal, power and cooling interface and testing fixture

TECHNICAL SCOPE:

Scientists, engineers, designers and students to design and build the v1 prototype for the Tracker. Tasks include design of the sensor, ladder, bus cable and interfaces. Procurement and fab of the v2 prototype are also covered . The v2 prototype ladder will be tested on the bench by scientists, students and techs. The tests will be evaluated in preparation for the next round of prototyping.

WORK STATEMENT:

Work covered by this WBS includes:

1. Specify prototype v2
2. Design ladder prototype v2
3. Design sensor prototype v2
4. Design bus cable prototype v2

5. Design power interface prototype v2
6. Design signal interface prototype v2
7. Design cooling interface prototype v2
8. Design review
9. Procure ladder v2
10. Procure bus cable v2
11. Procure sensor v2
12. Procure power, signal and cooling interface, v2
13. Assemble prototype v2
14. Test prototype v2
15. Evaluate the prototype test v2

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.03.02.03	Outer Tracker Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is labor from a scientist, engineers, designers and students to design, procure, fabricate, assemble and test the preproduction prototype of the Tracker outer layer ladders.

Material costs include costs for the ladder mechanics, silicon strip sensors, bus cable, signal, power and cooling interface and testing fixture

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the outer Tracker preproduction prototype . The preproduction prototype is one version of each type of ladder built as close as possible to the final version of the production ladders. Assembly fixtures that will be identical to those used in the final Tracker production will be designed and used for the preproduction. Components of the mechanical superstructure will also be constructed to assembly procedures and support schemes. Results of the testing will provide input to design changes for the production Trackers. All test results will be reviewed before giving approval to start final production.

WORK STATEMENT:

Work covered by this WBS includes:

1. Specify preproduction prototype design
2. Design ladder preproduction prototype

3. Design sensor preproduction prototype
4. Design bus cable preproduction prototype
5. Design power interface preproduction prototype
6. Design signal interface preproduction prototype
7. Design cooling interface preproduction prototype
8. Design review
9. Procure ladder for the preproduction prototype
10. Procure bus cable for the preproduction prototype
11. Procure sensor for the preproduction prototype
12. Procure power, signal and cooling interface for the preproduction prototype
13. Assemble prototype for the preproduction prototype
14. Test preproduction prototype
15. Evaluate the preproduction prototype test

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.03.03.01	Outer Tracker Ladder Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for scientists, engineers, designer, tech and student labor for Outer Tracker ladder production.

Material costs include production parts for the ladder, all sensors, bus cables, ladder and supermodule assembly fixtures, power components including cables, signal components including fibers and cables, cooling components including manifolds and test fixtures.

TECHNICAL SCOPE:

Scientist, engineers, technicians and students will procure all parts for ladder production and supermodules assembly. All ladders and supermodules will be build and tested. Outer Tracker factory prep, fabrication and of assembly and testing fixtures is part of the work scope.

WORK STATEMENT:

Tasks covered by this WBS include:

1. Factory and Shop Prep
2. Production Readiness Review
3. Procure production ladders
4. Procure production sensors
5. Procure production bus cables
6. Procure power components including cables

7. Procure cooling components including manifolds
8. Procure signal components Including cables and fibers
9. Procure parts for Assembly and Testing fixtures
10. Assemble all fixtures
11. Assemble all supermodules
12. Assemble production ladders
13. Test production ladders

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.03.03.02	Outer Tracker Layer Production and Assembly

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are for Scientists, engineers, techs and students to assemble the individual layers of the Outer Tracker and procure the Outer layer support systems.

Material costs are for the outer layer mech superstructure

TECHNICAL SCOPE:

Scientists, engineers, techs and students will procure the mechanical superstructure that will support the Outer layers (3-7) of the Tracker. They will assemble each layer individually out of the ladder supermodules, make registration adjustments and survey the ladder positions in each layer. Cooling and power support services to each Outer Tracker layer will also be completed.

WORK STATEMENT:

Tasks covered by this WBS include:

1. Procure Outer Layer Superstructure
2. Assemble, Register and Survey Layer 3
3. Assemble, Register and Survey Layer 4
4. Assemble, Register and Survey Layer 5
5. Assemble, Register and Survey Layer 6
6. Assemble, Register and Survey Layer 7
7. Assemble Layer Cooling Distribution
8. Assemble Layer Power Distribution

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.03.03.03	Outer Tracker Testing/Calibration/Integration

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor for testing, debugging and calibrating each of the individual layers (3-7) of the Outer Tracker. Labor is provided by scientists, engineers, techs and students

TECHNICAL SCOPE:

The scope of work is to test, debug and calibrate each of the individual layers of the outer tracker. The testing, debugging and calibrating must be complete before the assembly of the individual 5 strip layers into the Outer Tracker.

WORK STATEMENT:

The WBS tasks are:

1. Testing and debugging Outer Tracker layers 3 -7
2. Calibrating Outer Tracker layers 3-7

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.04	Tracker Assembly/Testing/Integration

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor is for scientists, engineers, techs and students to assemble the Outer Tracker, put the inner and outer tracker layers together, perform final tests and prep the Tracker for installation

Material costs are associated with the fixturing necessary to assemble the Outer tracker from the individual layers and to assemble the Inner and Outer Tracker together.

TECHNICAL SCOPE:

The scope of work is to assemble the 5 individual outer Tracker layers into the Outer Tracker. The Outer and Inner Tracker are then assembled together into a single structure. The Tracker is cabled, plumbed. Final tests are performed and the Tracker is Prepped installation into sPHENIX.

WORK STATEMENT:

The WBS tasks are:

1. Assemble Outer Layers into Outer Tracker
2. Integrate Inner and Outer Layers
3. Cable and Plumb Final Detector Assembly
4. Test and Debug Final Detector Assembly
5. Prep Si Tracker for Installation
6. Transport assembled Tracking modules to AH

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.01.01	Tracker sensor ASIC Specification

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost is to support the effort of an engineer and scientist to evaluate potential front end ASICs for the Tracker.

Modest material costs to support evaluation of existing ASICs.

TECHNICAL SCOPE:

An engineer and scientist with the help of a tech will evaluate potential ASICs for the Tracker front end. Work would involve obtaining samples of existing ASICs for testing and writing a performance spec.

WORK STATEMENT:

The WBS item s are:

1. Evaluate potential front end ASICs
2. Write an ASIC spec for the SiTracker

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.01.02	Tracker sensor ASIC procurement

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs cover the effort by an engineer and tech to prototype and procure ASICs for the Tracker front end.

Material costs cover ordering three rounds of ASIC prototypes, test stand equipment and the production ASIC.

TECHNICAL SCOPE:

Scientist, engineers and technicians will prototype and procure ASICs for the Tracker front end. The plan envisions the use of an existing ASIC that will require modest design modifications to be optimized for use with the sPHENIX Tracker. The modifications would need to be prototyped using a service such as MOSIS where early rounds of prototyping would be done through multi-project runs, and the preproduction round through a dedicated R&D run. The prototype round would be followed by a production run at the same foundary.

WORK STATEMENT:

The WBS tasks include:

1. Obtain quotes for ASIC for first prototype
2. Order prototype ASICs v1
3. Q/A delivered ASICs protoype v1
4. Obtain quotes for ASIC for second prototype
5. Order prototype v2 ASICs
6. Q/A delivered ASICs protoype v2
7. Obtain quotes for ASICs preproduction prototype
8. Order preproduction prototype ASICs

9. Q/A delivered ASICs protoype preproduction
10. Obtain quotes for production ASICs
11. Order production SiTracking ASICs
12. Q/A delivered SiTracking production ASICs

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	Tracker sensor ASIC Testing

4. WBS Element Code	5. WBS Element Title
1.04.05.01.03	

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs cover work by scientists, engineers, designers, techs and students to build a test set up for the ASICs and to test and select all ASICs.

TECHNICAL SCOPE:

The work scope includes the design and fab of an ASIC test set-up, and the testing of all ASICs

WORK STATEMENT:

The WBS tasks are:

1. Design and build ASIC test stand
2. Test and select all ASICs

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.02.01	Tracker ROC design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs cover the effort of a scientist and engineer to design the Read Our Card for the Tracker. The design effort covers three rounds of prototype design plus the production design.

TECHNICAL SCOPE:

The technical scope covers writing the ROC spec, ROC design work through three rounds of prototyping plus production, design of the LV power system, signal and power cables.

WORK STATEMENT:

WBS tasks are:

Write design specification: prototype v1

Design SiTracking ROC: protoype v1

Layout SiTracking ROC motherboad: prototype v1

Specify signal and power cables for SiTracking ROC prototype v1

Specify power system for SiTracking ROC: prototype v1

Review and write design specification:, prototype v2

Design SiTracking ROC protoype v2

Layout SiTracking ROC prototype v2

Specify signal and power cables for SiTracking ROC: prototype v2

Specify power system for SiTracking ROC : prototype v2

Review and write design specifications: preproduction prototype

Design SiTracking ROC preproduction prototype

Layout SiTracking ROC preproduction prototype

Specify signal and power cables for SiTracking ROC: preproduction prototype

Specify power system for SiTracking ROC: preproduction prototype

Review and write design specifications: production

Design SiTracking production ROC

Layout SiTracking Production ROC

Specify signal and power cables for SiTracking ROC: production.

Specify power system for SiTracking: production

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.02.02.01	Tracker ROC Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v1, and write design change specifications for prototype v1 . Engineer to assemble, test and write design change specifications. Technician to oversee procurement of components, assembly of all PCB boards, and assist with final assembly and testing of prototype v1 electronics . A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing and writing design change specifications for prototype v1. Test results will be used for writing design change specifications for the prototype v2 electronics

WORK STATEMENT:

This WBS items covers the assembly of a prototype v1. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v1 prototype. Bench testing includes testing of readout card, interface to ASIC, and connection to FEM. Heat and power loads are also measured to estimate cooling requirements for the FEM racks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional prototype v1, design change specifications for prototype v2, and estimated power and heat loads.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.02.02.02	Tracker ROC Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v2, and write design change specifications for preproduction prototype Engineer to assemble, test and write design change specifications Technician to oversee procurement of components, assembly of all PCB boards and assist with final assembly and testing of prototype v2 electronics . A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing of a prototype v2. Test results will be used for writing design change specifications for the preproduction prototype FEM electronics

WORK STATEMENT:

This WBS items covers the assembly of a prototype v2. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v2 prototype. Bench testing includes testing of ROC, interface with the ASIC, and connection to the FEM. Heat and power loads are also measured to estimate cooling requirements.acks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional prototype v2, design change specifications for preproduction prototype, and estimated power and heat loads for the FEM system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.02.02.03	Tracker ROC Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of preproduction prototype, and write design change specifications for production Engineer to assemble, test and write design change specifications Technician to oversee procurement of components, assembly of all PCB boards and assist with final assembly and testing of the preproduction prototype electronics A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, and testing change for a preproduction prototype. Test results will be used for writing design change specifications for the production FEM electronics

WORK STATEMENT:

This WBS items covers the assembly of a preproduction prototype. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the preproduction prototype. The testing is to be done as part of a full system chain test including preproduction Tracker ladder or supermodule, ASIC, preproduction FEM and and DCM readout. Heat and power loads are also measured to determine cooling requirements for the FEM racks. Design specification changes are written based on chain tests.

Deliverables include: Fully functional preproduction prototype, design change specifications for production prototype, and final power and heat loads for the ROC.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.02.03	Tracker ROC Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost: Scientist to review final design specifications and test results of production electronics Engineer to oversee and manage the procurement of all components, PCB board fabrication and final assembly of production ROC for the Tracker. Designer to assist with final design review and modifications for production. Technician for procurement of components and detailed oversight of board fabrication and work on final assembly of production electronics Material cost include: Production costs assume that commercial vendor is used for all PCB board fabrication. Project engineers and technicians do final system assembly and testing. Component cost includes a 10% loss due to yield. No spare modules are included the cost.

TECHNICAL SCOPE:

This WBS item includes the procurement of all components, final assembly and testing of the production electronics for the ROC . There are a total of boards for the ??? .

WORK STATEMENT:

This WBS item covers the full production of the Tracker ROC for the sPHENIX . Prior to start of production, a readiness review is to be conducted to insure that the system meets the design requirements for the sPHENIX Tracker FEM system. The procurement process includes obtaining quotes for all components necessary for the ROC, placing purchase requisitions for components, tracking deliver of components and Q/A of delivered components. The fabrication and assembly stage covers the assembly of all PC boards required for the Tracker ROC. The testing stage covers the testing of ROCs for the sPHENIX detectors.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.03.01	Tracker FEM design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only: The efforts of scientists, engineers and designers will be used to design all boards and crates associated with the Tracker FEM. Costs cover the labor needed to design three phases of prototypes v1, v2 and preproduction plus the final production stage.

TECHNICAL SCOPE:

Scope includes three design rounds of prototyping plus the production design of the FEM board, XMIT board, crate controller, master clock, and crate including the backplane.

WORK STATEMENT:

1. Tasks included in this WBS are:
2. Write design specifications for SiTracking FEM system
3. Design FEM Boards: Prototype v1
4. Design Clock Master Board: Prototype v1
5. Design XMIT Board: Prototype v1
6. Design Crate: Prototype V1
7. Layout FEM Board: Prototype v1
8. Layout Crate Controller Board: Prototype v1
9. Layout Crate Controller Board: Prototype v1
10. Layout XMIT Board: Prototype v1
11. Review and write design change specifications for Tracker FEM system: prototype v2
12. Design FEM Boards: Prototype v2
13. Design Clock Master Board: Prototype v2

14. Design XMIT Board: Prototype v2
15. Design Crate: Prototype v2
16. Layout FEM Board: Prototype v2
17. Layout Clock Master Board: Prototype v2
18. Layout XMIT Board: Prototype v2
19. Write design change specifications for Tracker FEM system: preproduction prototype
20. Design FEM Boards: Preproduction Prototype
21. Design Clock Master Board: Preproduction Prototype
22. Design XMIT Board: Preproduction Prototype
23. Design Crate: Preproduction Prototype
24. Layout FEM Board: Preproduction Prototype
25. Layout Clock Master Board: Preproduction Prototype
26. Layout XMIT Board: Preproduction Prototype
27. Write design change specifications for Tracker FEM system: production
28. Design XMIT Board: Production
29. Design Crate: Preproduction
30. Layout FEM Board: Production
31. Layout Clock Master Board: Production
32. Layout XMIT Board: Production

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.03.02.01	Tracker FEM Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v1, and write design change specifications for prototype v2 (25%). Engineer to assemble, test and write design change specifications (25%). Technician to oversee procurement of components, assembly of all PCB boards (10%), and assist with final assembly and testing of prototype v1 electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing and writing design change specifications for prototype v1. Test results will be used for writing design change specifications for the prototype v2 electronics

WORK STATEMENT:

This WBS items covers the assembly of a prototype v1. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v1 prototype. Bench testing includes testing of FEMs, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to estimate cooling requirements for the FEM racks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional prototype v1, design change specifications for prototype v2, and estimated power and heat loads for the FEMs system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.03.02.02	Tracker FEM Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v2, and write design change specifications for preproduction prototype Engineer to assemble, test and write design change specifications Technician to oversee procurement of components, assembly of all PCB boards and assist with final assembly and testing of prototype v2 electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing of a prototype v2. Test results will be used for writing design change specifications for the preproduction prototype FEMs electronics

WORK STATEMENT:

This WBS items covers the assembly of a prototype v2. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v2 prototype. Bench testing includes testing of FEMs, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to estimate cooling requirements for the FEMs racks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional prototype v2, design change specifications for preproduction prototype, and estimated power and heat loads for the FEMs system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.03.02.03	Tracker FEM Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of preproduction prototype, and write design change specifications for production Engineer to assemble, test and write design change specifications Technician to oversee procurement of components, assembly of all PCB boards and assist with final assembly and testing of the preproduction prototype electronics A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, and testing change for a preproduction prototype. Test results will be used for writing design change specifications for the production FEMs electronics

WORK STATEMENT:

This WBS items covers the assembly of a preproduction prototype. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the preproduction prototype. The testing is to be done as part of a full system chain test including detectors, preproduction frontend electronics and DCM readout. Testing includes testing of frontend FEMs, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to determine cooling requirements for the FEMs racks. Design specification changes are written based on chain tests.

Deliverables include: Fully functional preproduction prototype, design change

specifications for production prototype, and final power and heat loads for the FEM system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	

4. WBS Element Code	5. WBS Element Title
1.04.05.03.03	Tracker FEM Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost: Scientist to review final design specifications and test results of production electronics. Engineer to oversee and manage the procurement of all components, PCB board fabrication and final assembly of production FEM system for the Tracker. Designer to assist with final design review and modifications for production (25%). Technician for procurement of components and detailed oversight of board fabrication (10%) and work on final assembly of production electronics Material cost include: Production costs assume that commercial vendor is used for all PCB board fabrication. Project engineers and technicians do final system assembly and testing. Component cost includes a 10% loss due to yield. No spare modules are included the cost.

TECHNICAL SCOPE:

This WBS item includes the procurement of all components, final assembly and testing of the production electronics for the Tracker . There are ??? total of boards for the Tracker . Each crate has 1 controller board. There are a total of ??? boards for the Tracker located in ??? crates, with each crate having a controller board and XMIT board.

WORK STATEMENT:

This WBS item covers the full production of the Tracker for sPHENIX . Prior to start of production, a readiness review is to be conducted to insure that the system meets the design requirements for the sPHENIX Tracker FEM system. The procurement process includes obtaining quotes for all components necessary for the FEM system, placing purchase requisitions for components, tracking deliver of components and Q/A of delivered components. The fabrication and assembly stage covers the assembly of all PC boards required for the FEM system, assembly of

crates and power supplies and installation of system boards into crates for testing. The testing stage covers the testing crates for the sPHENIX detectors

Deliverables: ??? of fully tested Tracker FEM boards , associated power supplies and cables for installation into the sPHENIX detector.

sPHENIX	03/06/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.1	EMCAL Management

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

Management of the EMCAL system contains oversight of the construction project as well as coordination with the experimental collaboration and making certain that the as-built detector configuration is capable of carrying out the physics program of the collaboration. Preparation of cost and schedule data for design, safety, and installation reviews as well as for monitoring the progress of the construction is captured in this WBS.

WORK STATEMENT:

- Preparation of documentation for reviews.
- Preparation of cost and schedule data.

sPHENIX	03/09/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.2	EMCAL design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package captures the entire Electromagnetic Calorimeter design, including the design of all mechanical and support systems, the tungsten powder, epoxy, and scintillating fiber absorber, the light collection and readout systems, and all auxiliary systems such as calibration and cooling.

WORK STATEMENT:

- Mechanical design of the EMCAL, including interfaces with the Installation and Infrastructure task, which will provide mechanical support and assembly methodology for the EMCAL inside the solenoid, will be fully captured by this WBS item.
- Analysis of the structure including gravitational loading and static and dynamic forces on the structure from the magnetic field.
- Design of cable management for signal and bias voltage cables exiting the detector volume.
- Design of the tungsten powder epoxy scintillating fiber absorber and its light guides, including whatever components are needed to connect the SiPM's to the light guides.
- Preparation of all documentation for design and safety reviews.
- Carry out design and safety reviews for the EMCAL.

sPHENIX	03/09/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.3.1	EMCAL prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities and materials needed to build a first prototype of the Electromagnetic Calorimeter. The prototype will consist of a matrix of tungsten powder and epoxy with embedded scintillating fibers that is divided into approximately 2x2 cm2 towers that are read out with silicon photomultipliers (SiPMs). The deliverable resulting from this work will be a 4x6 array of towers that are projective in one direction. The resulting prototype will be capable of being coupled to the digitizer system being developed for sPHENIX (which is not part of the technical scope of this WBS line). The prototype will be capable of measuring electron energies up to 32 GeV and will include a light pulser calibration system for monitoring the gain of each channel. Design of electronics and cabling for this prototype is not part of the technical scope, but are provided by the calorimeter electronics design and prototyping tasks.

The test program will consist of testing with the light pulser system and cosmic ray triggers. Operation in a beamline, most likely the Fermilab Test Beam Facility, will be carried out in concert with the Inner and Outer HCAL prototypes.

WORK STATEMENT:

- Mechanical design of the absorber modules which will be constructed in 1x2 tower blocks
- Design of light pulser calibration system
- Procurement of the tungsten powder, epoxy and scintillating fibers.
- Procurement of light guides for towers
- Procurement of parts for light pulser calibration system
- Procurement of light tight enclosure

- Design and fabrication of miscellaneous mechanical parts
- Fabrication of the twelve 1x2 tower blocks
- Assembly of the 4x6 tower array
- Installation of light guides, SiPMs and readout electronics
- Final assembly of prototype
- Lab testing of prototype with light flasher system and cosmic rays
- Beam test of prototype

All design work needed to fabricate a prototype calorimeter is captured by this WBS line. A minimal amount of engineering is expected to be required because the prototype is relatively small.

Procurement of all the mechanical components of the prototype calorimeter is captured by this WBS item.

sPHENIX	03/09/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.3.2	ECAL prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities and materials needed to build a second prototype of the Electromagnetic Calorimeter. The prototype will consist of a matrix of tungsten powder and epoxy with embedded scintillating fibers that is divided into approximately 2x2 cm2 towers that are read out with silicon photomultipliers (SiPMs). The deliverable resulting from this work will be an array of towers that are projective in two directions (azimuth and pseudorapidity η). The resulting prototype will be capable of being coupled to the digitizer system being developed for sPHENIX (which is not part of the technical scope of this WBS line). The prototype will be capable of measuring electron energies up to 32 GeV and will include a light pulser calibration system for monitoring the gain of each channel. Design of electronics and cabling for this prototype is not part of the technical scope, but are provided by the calorimeter electronics design and prototyping tasks.

The second EMCAL prototype will be designed to test the response of a fully projective calorimeter. This WBS line differs from the first v1 prototype insofar as it allows testing near the maximum pseudorapidity subtended by the final calorimeter, i.e., near $\eta \sim 1$, equivalent to a polar angle of about 40°. It may require several different tower arrays in order to accomplish this.

The test program will consist of testing with the light pulser system and cosmic ray triggers. Operation in a beamline, most likely the Fermilab Test Beam Facility, will be carried out in concert with the Inner and Outer HCAL prototypes.

WORK STATEMENT:

- Mechanical design of the 2D projective tower modules
- Develop procedure for producing 2D projective modules
- Make any design modifications of the light pulser calibration system
- Procurement of the tungsten powder, epoxy and scintillating fibers.
- Procurement of light guides for towers
- Procurement of any additional parts for light pulser calibration system
- Procurement of light tight enclosure and support structure
- Fabrication of the tower modules
- Assembly of tower modules
- Installation of light guides, SiPMs and readout electronics
- Final assembly of prototype
- Lab testing of prototype with light flasher system and cosmic rays
- Beam test of prototype

All design work needed to fabricate this prototype calorimeter is captured by this WBS line. Procurement of all the mechanical components of the prototype calorimeter is captured by this WBS item.

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sPHENIX	03/09/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.3.3	EMCAL preproduction prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities needed to design, procure, and manufacture a full sized prototype sector the Electromagnetic Calorimeter. A sector will be one of 64 sectors which will comprise the EMCAL (32 in azimuth on each side of the spectrometer). The deliverable for this WBS item will be a full sized sector consisting of 24 modules. Each module will consist of an array of 2x8 towers designed to cover a specific region of pseudorapidity. The entire sector will cover one half of the pseudorapidity and one slice of the azimuthal angle of the final calorimeter. The construction of this preproduction prototype sector will test the manufacturing and assembly procedure for producing all of the modules needed for the final calorimeter. It will also test the installation procedure, cable management, and performance of the electronic readout and light pulser calibration systems. Due to its physical size and weight (~ 700 lbs), it will also require designing and testing certain lifting fixtures.

The EMCAL preproduction prototype will be designed to test the calorimeter response over the full rapidity coverage of the final calorimeter. It will also test the production and assembly procedure for constructing an entire sector.

The test program will consist of testing with the light pulser system and cosmic ray triggers. Operation in a beamline, most likely the Fermilab Test Beam Facility, will be carried out in concert with the Inner and Outer HCAL preproduction prototypes.

WORK STATEMENT:

- All mechanical designs of a sector necessary to install it in sPHENIX consistent with the Infrastructure and Installation task is contained in this WBS line. Installation tooling is to be produced as part of the Infrastructure and Installation task.
- Preparation of lifting fixtures, support tables, and workspace needed both for assembly and testing is captured here.
- All activities needed to procure the absorber (tungsten powder, epoxy and scintillating fibers) and any fixtures or devices needed to construct the sector are contained in this WBS line. Thus, all design efforts needed to create production ready drawings are deliverables.
- The full scale preproduction prototype sector will initially be tested in the lab using the light pulser system and with cosmic rays. It will then be tested in the beam along with the preproduction prototypes of the Inner and Outer HCAL. The EMCAL prototype would be instrumented over the full azimuthal and pseudorapidity range of one sector of the final calorimeter, while it is envisioned that the two HCAL prototypes may be instrumented over only part of this range.

sPHENIX	03/09/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.4.1	EMCAL module production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

EMCAL module production consists of all activities needed to take the EMCAL design (completed under WBS item 1.5.2) and complete the construction of all modules required for the 64 sectors of the final calorimeter that can be delivered to the sPHENIX Assembly Hall for installation in the detector. Since design activities will be complete, this WBS line captures the effort needed to actually produce the modules, including the manufacture of any additional handling fixtures. Procurement and delivery of all materials needed to fabricate the modules are contained in this WBS line, including the production of the light guides and any assemblies needed to couple the photodetectors to the light guides.

WORK STATEMENT:

- Procurement and acceptance verification of parts needed to construct the EMCAL modules, including
  - Tungsten powder and epoxy absorber
  - Scintillating fibers
  - Light collection hardware
  - Cable management hardware
- Preparation of workspaces need for assembly of EMCAL modules
- Preparation of any storage needed while modules await assembly

sPHENIX	03/09/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.4.2	EMCAL module assembly

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This WBS line is meant to capture all the activities needed to take the EMCAL module components procured under WBS 1.5.4.1 and assemble them into operational sectors which can be tested as part of WBS 1.5.4.3. The major part of the work will consist of assembling parts (absorber, light collection and SiPM's) and providing workspace for acceptance testing of the modules.

WORK STATEMENT:

- Absorber blocks will be assembled into modules
- Light guides will be attached to each tower
- SiPMs and front end electronic readout will be installed
- Calibration system will be installed
- Modules will be installed into sectors.
- Remaining parts of calibration and cooling system will be installed
- Cable management and preparation for acceptance testing.
- Completing sector assembly with light-tight covers making each sector individually capable of being tested

sPHENIX	03/09/2015	C.Woody, S.Stoll

4. WBS Element Code	5. WBS Element Title
1.5.4.3	EMCAL module/testing/calibration/integration

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

Fully assembled sectors of EMCAL modules are tested and calibrated with the light pulser system and cosmic rays. In order to accomplish this, the controller is powered and bias is supplied by the production bias supply. Measurements of the leakage currents from each calorimeter tower are made and recorded.

Acceptance criteria require that any bias current draw outside three sigma of the mean observed in the prototypes is investigated and repaired if necessary. Testing with the preamplifier test pulse and light pulser are used to verify that each channel is working.

WORK STATEMENT:

- Connection of power, bias cables, communication, and signal cables to preamplifiers, and connection to one or more test racks of electronics.
- Measurement of bias current and debugging of any mis-connected photodetectors or light leaks.
- Measurement of light pulses from each channel
- Setup of trigger counters for cosmic ray testing.
- Collection of cosmic ray data from all channels.
- Data logging and record keeping for each module.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.01	HCAL Management

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

Management of the HCAL system contains oversight of the construction project as well as coordination with the experimental collaboration and making certain that the as-built detector configuration is capable of carrying out the physics program of the collaboration. Preparation of cost and schedule data for design, safety, and installation reviews as well as for monitoring the progress of the construction is captured in this WBS.

WORK STATEMENT:

- Preparation of documentation for reviews.
- Preparation of cost and schedule data.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.02.01	Inner HCAL design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

The Inner HCAL detector will be fully designed mechanically, both the absorber plates, constructed out of materials which have been demonstrated to have minimal effect on the 1.5 T magnetic field, and the scintillator tiles which are inserted into slots between the tapered steel plates.

WORK STATEMENT:

- Mechanical design of the inner HCAL, including interfaces with the Installation and Infrastructure task, which will provide mechanical support and assembly methodology for the Inner HCAL inside the solenoid will be fully captured by this WBS item.
- Analysis of the structure including gravitational loading and static and dynamic forces on the structure from the magnetic field.
- Design of cable management for signal cables exiting the detector volume.
- Design of the scintillator tiles, including whatever components are needed to connect the SiPM's to the tiles.
- Preparation of all documentation for design and safety reviews.
- Carry out design and safety reviews for the Inner HCAL.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.02.02.01	Inner HCAL prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities and materials needed to build a working prototype of the Inner Hadronic Calorimeter. The deliverable resulting from this work is an approximately 5x5 cell hadronic calorimeter complete with scintillator tiles with embedded wavelength shifting fiber coupled to silicon photomultipliers, preamps, and cables to the digitizer system. The resulting calorimeter prototype will be capable of being coupled to the digitizer system being developed for sPHENIX (which is not part of the technical scope of this WBS line). The output from the preamplifiers will be capable of detecting signals from minimum ionizing cosmic ray muons traversing the scintillator up to the energy deposition expected from a 60 GeV pion or proton. Provision will be made for LED flashers on every electronic channel which can be used to assess the health of the signal chain. The prototype will include provision for mechanical support in a beamline as well as any rigging fixtures which may be required. Design of electronics and cabling for this prototype are not part of the technical scope, but are provided by the calorimeter electronics design and prototyping tasks.

The test program will consist of testing with an LED flasher system and cosmic ray triggers. Operation in a beamline, most likely the Fermilab Test Beam Facility, will be carried out in concert with the Electromagnetic Calorimeter and Outer HCAL prototypes.

WORK STATEMENT:

- Mechanical design of absorber plates with provision for spacers providing clearance for insertion of scintillator tiles.

- Procurement of absorber plates.
- Mechanical design of scintillator tiles including routing of WLS fiber and provision for light collection to silicon photomultipliers.
- Procurement of scintillator tiles.
- Specification and design of light collector and silicon photomultiplier support with connection to preampliers.
- Procurement of light collector components and coupling to scintillator tiles.
- Design, procurement, and construction of light tight and protective enclosure for calorimeter.

All design work needed to fabricate a prototype calorimeter is captured by this WBS line. A rather minimal amount of engineering is expected to be required because the prototype is relatively small.

Procurement of all the mechanical components of the prototype calorimeter is captured by this WBS item.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.02.02.02	Inner HCAL prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities and materials needed to build a working prototype of the Inner Hadronic Calorimeter. The deliverable resulting from this work is an approximately 5x5 cell hadronic calorimeter complete with scintillator tiles with embedded wavelength shifting fiber coupled to silicon photomultipliers, preamps, and cables to the digitizer system. The resulting calorimeter prototype will be capable of being coupled to the digitizer system being developed for sPHENIX (which is not part of the technical scope of this WBS line). The output from the preamplifiers will be capable of detecting signals from minimum ionizing cosmic ray muons traversing the scintillator up to the energy deposition expected from a 60 GeV pion or proton. Provision will be made for LED flashers on every electronic channel which can be used to assess the health of the signal chain. The prototype will include provision for mechanical support in a beamline. Design of electronics and cabling for this prototype are not part of the technical scope, but are provided by the design and prototyping tasks.

This WBS line differs from the Inner HCAL v1 prototype insofar as it allows testing near the maximum pseudorapidity subtended by the calorimeter module, i.e., near $\eta \sim 1$, equivalent to a polar angle of about 40°. It may be possible to reconfigure the absorber needed for the v1 prototype to accomplish this goal by replacing the scintillator tiles.

The test program will consist of testing with an LED flasher system and cosmic ray triggers. Operation in a beamline, most likely the Fermilab Test Beam Facility, will be carried out in concert with the Electromagnetic Calorimeter and Outer HCAL prototypes.

WORK STATEMENT:

- Mechanical design of absorber plates with provision for spacers providing clearance for insertion of scintillator tiles.
- Procurement of absorber plates.
- Mechanical design of scintillator tiles including routing of WLS fiber and provision for light collection to silicon photomultipliers.
- Procurement of scintillator tiles.
- Specification and design of light collector and silicon photomultiplier support with connection to preampliers.
- Procurement of light collector components and coupling to scintillator tiles.
- Design, procurement, and construction of light tight and protective enclosure for calorimeter.
- Attachment of preamplifier modules and cables to bring signals to the digitizer system.

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sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.02.02.03	Inner HCAL preproduction prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities needed to design, procure, and manufacture a full sized prototype sector the Inner Hadronic Calorimeter. A sector will be one of 32 sectors which will comprise the Inner HCAL. The deliverable for this WBS item will be a full sized sector populated partially with scintillating tiles (a minimum of once tower, with as many as six towers covering one half of the rapidity and one slice of azimuthal angle) that can be used to make mechanical measurements of the sector, develop handling and manufacturing techniques, and demonstrate cable management and light tighting methodology.

Development of handling techniques and lifting fixtures for transport and storage.

The testing will consist of measurements of the mechanical deformations of the structure and LED and cosmic ray tests of the active towers.

WORK STATEMENT:

- All mechanical design of a module necessary to install it in sPHENIX consistent with the Infrastructure and Installation task is contained in this WBS line. Installation tooling is to be produced as part of the Infrastructure and Installation task.
- Preparation of lifting fixtures, support tables, and workspace needed both for assembly and testing is captured here.
- All activities needed to procure the absorber and any fixtures or devices needed to construct a module are contained in this WBS line. Thus, all design effort needed to create production ready drawings are deliverable.
- Since it is unlikely that the full sized prototype module could be beam tested, it may not be necessary to populate it fully with scintillator tiles.

However, a minimum of one complete calorimeter cell (five tiles) should be populated, and provision should be made for adding additional tiles for mechanical and cosmic ray testing.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title	
1.06.02.03.01	Inner HCAL module production	
6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

Inner HCAL module production consists of all activities needed to take the Inner HCAL design (completed under WBS item 1.06.02.01) and complete construction of 32 modules that can be delivered to the sPHENIX Assembly Hall for installation in the detector. Since design activities will be complete, this WBS line captures the effort needed to actually produce the modules, including procurement of the absorber, procurement of any mechanical parts needed to assemble and strengthen the absorber into a rigid structure, and manufacture of any additional handling fixtures needed to construct the modules. Procurement and delivery of scintillator tiles with embedded WLS fiber designed under WBS 1.06.01.01 is contained in this WBS line, as well as production of any assemblies needed to couple the photodetectors to the scintillating tiles.

WORK STATEMENT:

- Procurement and acceptance verification of parts needed to construct the Inner HCAL modules, including
  - Absorber plates
  - Scintillating tiles
  - Light collection hardware
  - Cable management hardware
- Preparation of workspaces need for assembly in Inner HCAL modules
- Preparation of any storage needed while modules await assembly

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.02.03.02	Inner HCAL module assembly

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This WBS line is meant to capture all the activities needed to take the Inner HCAL module components procured under WMS 1.06.02.03.01 and assemble them into operational modules which can be tested as part of WBS 1.06.02.03.03. the major part of the work will consist of assembling parts (absorber, scintillator tiles, light collection and SiPM's) and providing workspace for acceptance testing of the modules.

WORK STATEMENT:

- Stacking of absorber in a horizontal orientation in several stations of assembly.
- Insertion of scintillator tiles with light collection assemblies already integrated.
- Connection of light collectors to preamplifier cables.
- Connection of preamplifiers to controller modules (providing temperature measurement and compensation.
- Connection of LED pulser system.
- Cable management and preparation for acceptance testing.
- Completing module construction with light-tight covers making each module individually capable of test.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.02.03.03	Inner HCAL module/testing/calibration/integration

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

Fully assembled Inner HCAL modules are tested and calibrated by the LED pulser system and with cosmic ray data. In order to accomplish this, the controller is powered an bias is supplied by the production bias supply. Measurements of the leakage currents from each calorimeter cell are made and recorded.

Acceptance criteria require that any bias current draw outside three sigma of the mean observed in the prototypes is investigated and repaired if necessary. Testing with the preamplifier test pulse and LED light pulser are used to verify that each channel is alive and that all five scintillator tiles are functional.

WORK STATEMENT:

- Connection of power, bias cables, communication, and signal cables to preamplifiers, and connection to one or more test racks of electronics.
- Measurement of bias current and debugging of any mis-connected photodetectors or light leaks.
- Measurement of LED pulses from each channel
- Setup of trigger counters for cosmic ray testing.
- Collection of cosmic ray data from all channels.
- Data logging and record keeping for each module.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.03.01	Outer HCAL design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

The Outer HCAL detector will be fully designed mechanically, both the absorber plates, constructed out of materials which have been demonstrated to have minimal effect on the 1.5 T magnetic field, and the scintillator tiles which are inserted into slots between the tapered steel plates.

WORK STATEMENT:

- Mechanical design of the Outer HCAL, including interfaces with the Installation and Infrastructure task, which will provide mechanical support and assembly methodology for the Outer HCAL inside the solenoid will be fully captured by this WBS item.
- Analysis of the structure including gravitational loading and static and dynamic forces on the structure from the magnetic field.
- Design of cable management for signal cables exiting the detector volume.
- Design of the scintillator tiles, including whatever components are needed to connect the SiPM's to the tiles.
- Preparation of all documentation for design and safety reviews.
- Carry out design and safety reviews for the Outer HCAL.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.03.02.01	Outer HCAL prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities and materials needed to build a working prototype of the Outer Hadronic Calorimeter. The deliverable resulting from this work is an approximately 5x5 cell hadronic calorimeter complete with scintillator tiles with embedded wavelength shifting fiber coupled to silicon photomultipliers, preamps, and cables to the digitizer system. The resulting calorimeter prototype will be capable of being coupled to the digitizer system being developed for sPHENIX (which is not part of the technical scope of this WBS line). The output from the preamplifiers will be capable of detecting signals from minimum ionizing cosmic ray muons traversing the scintillator up to the energy deposition expected from a 60 GeV pion or proton. Provision will be made for LED flashers on every electronic channel which can be used to assess the health of the signal chain. The prototype will include provision for mechanical support in a beamline as well as any rigging fixtures which may be required. Design of electronics and cabling for this prototype are not part of the technical scope, but are provided by the calorimeter electronics design and prototyping tasks.

The test program will consist of testing with an LED flasher system and cosmic ray triggers. Operation in a beamline, most likely the Fermilab Test Beam Facility, will be carried out in concert with the Electromagnetic Calorimeter and Outer HCAL prototypes.

WORK STATEMENT:

- Mechanical design of absorber plates with provision for spacers providing clearance for insertion of scintillator tiles.
- Procurement of absorber plates.

- Mechanical design of scintillator tiles including routing of WLS fiber and provision for light collection to silicon photomultipliers.
- Procurement of scintillator tiles.
- Specification and design of light collector and silicon photomultiplier support with connection to preampliers.
- Procurement of light collector components and coupling to scintillator tiles.
- Design, procurement, and construction of light tight and protective enclosure for calorimeter.

All design work needed to fabricate a prototype calorimeter is captured by this WBS line. A rather minimal amount of engineering is expected to be required because the prototype is relatively small.

Procurement of all the mechanical components of the prototype calorimeter is captured by this WBS item.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.03.02.02	Outer HCAL prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities and materials needed to build a working prototype of the Outer Hadronic Calorimeter. The deliverable resulting from this work is an approximately 5x5 cell hadronic calorimeter complete with scintillator tiles with embedded wavelength shifting fiber coupled to silicon photomultipliers, preamps, and cables to the digitizer system. The resulting calorimeter prototype will be capable of being coupled to the digitizer system being developed for sPHENIX (which is not part of the technical scope of this WBS line). The output from the preamplifiers will be capable of detecting signals from minimum ionizing cosmic ray muons traversing the scintillator up to the energy deposition expected from a 60 GeV pion or proton. Provision will be made for LED flashers on every electronic channel which can be used to assess the health of the signal chain. The prototype will include provision for mechanical support in a beamline. Design of electronics and cabling for this prototype are not part of the technical scope, but are provided by the design and prototyping tasks.

This WBS line differs from the Outer HCAL v1 prototype insofar as it allows testing near the maximum pseudorapidity subtended by the calorimeter module, i.e., near $\eta \sim 1$, equivalent to a polar angle of about 40°. It may be possible to reconfigure the absorber needed for the v1 prototype to accomplish this goal by replacing the scintillator tiles.

The test program will consist of testing with an LED flasher system and cosmic ray triggers. Operation in a beamline, most likely the Fermilab Test Beam Facility, will be carried out in concert with the Electromagnetic Calorimeter and Outer HCAL prototypes.

WORK STATEMENT:

- Mechanical design of absorber plates with provision for spacers providing clearance for insertion of scintillator tiles.
- Procurement of absorber plates.
- Mechanical design of scintillator tiles including routing of WLS fiber and provision for light collection to silicon photomultipliers.
- Procurement of scintillator tiles.
- Specification and design of light collector and silicon photomultiplier support with connection to preampliers.
- Procurement of light collector components and coupling to scintillator tiles.
- Design, procurement, and construction of light tight and protective enclosure for calorimeter.
- Attachment of preamplifier modules and cables to bring signals to the digitizer system.

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sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.03.02.03	Outer HCAL preproduction prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This work package consists of all activities needed to design, procure, and manufacture a full sized prototype sector the Outer Hadronic Calorimeter. A sector will be one of 32 sectors which will comprise the Outer HCAL. The deliverable for this WBS item will be a full sized sector populated partially with scintillating tiles (a minimum of once tower, with as many as six towers covering one half of the rapidity and one slice of azimuthal angle) that can be used to make mechanical measurements of the sector, develop handling and manufacturing techniques, and demonstrate cable management and light tighting methodology.

Development of handling techniques and lifting fixtures for transport and storage.

The testing will consist of measurements of the mechanical deformations of the structure and LED and cosmic ray tests of the active towers.

WORK STATEMENT:

- All mechanical design of a module necessary to install it in sPHENIX consistent with the Infrastructure and Installation task is contained in this WBS line. Installation tooling is to be produced as part of the Infrastructure and Installation task.
- Preparation of lifting fixtures, support tables, and workspace needed both for assembly and testing is captured here.
- All activities needed to procure the absorber and any fixtures or devices needed to construct a module are contained in this WBS line. Thus, all design effort needed to create production ready drawings are deliverable.
- Since it is unlikely that the full sized prototype module could be beam tested, it may not be necessary to populate it fully with scintillator tiles.

However, a minimum of one complete calorimeter cell (five tiles) should be populated, and provision should be made for adding additional tiles for mechanical and cosmic ray testing.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.03.03.01	Outer HCAL module production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

Outer HCAL module production consists of all activities needed to take the Outer HCAL design (completed under WBS item 1.06.02.01) and complete construction of 32 modules that can be delivered to the sPHENIX Assembly Hall for installation in the detector. Since design activities will be complete, this WBS line captures the effort needed to actually produce the modules, including procurement of the absorber, procurement of any mechanical parts needed to assemble and strengthen the absorber into a rigid structure, and manufacture of any additional handling fixtures needed to construct the modules. Procurement and delivery of scintillator tiles with embedded WLS fiber designed under WBS 1.06.01.01 is contained in this WBS line, as well as production of any assemblies needed to couple the photodetectors to the scintillating tiles.

WORK STATEMENT:

- Procurement and acceptance verification of parts needed to construct the Outer HCAL modules, including
  - Absorber plates
  - Scintillating tiles
  - Light collection hardware
  - Cable management hardware
- Preparation of workspaces need for assembly in Outer HCAL modules
- Preparation of any storage needed while modules await assembly

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.03.03.02	Outer HCAL module assembly

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

This WBS line is meant to capture all the activities needed to take the Outer HCAL module components procured under WMS 1.06.02.03.01 and assemble them into operational modules which can be tested as part of WBS 1.06.02.03.03. the major part of the work will consist of assembling parts (absorber, scintillator tiles, light collection and SiPM's) and providing workspace for acceptance testing of the modules.

WORK STATEMENT:

- Stacking of absorber in a horizontal orientation in several stations of assembly.
- Insertion of scintillator tiles with light collection assemblies already integrated.
- Connection of light collectors to preamplifier cables.
- Connection of preamplifiers to controller modules (providing temperature measurement and compensation.
- Connection of LED pulser system.
- Cable management and preparation for acceptance testing.
- Completing module construction with light-tight covers making each module individually capable of test.

sPHENIX	02/23/2015	E. Kistenev, J. Lajoie, J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.06.03.03.03	Outer HCAL module/testing/calibration/integration

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

TECHNICAL SCOPE:

Fully assembled Outer HCAL modules are tested and calibrated by the LED pulser system and with cosmic ray data. In order to accomplish this, the controller is powered an bias is supplied by the production bias supply. Measurements of the leakage currents from each calorimeter cell are made and recorded.

Acceptance criteria require that any bias current draw outside three sigma of the mean observed in the prototypes is investigated and repaired if necessary. Testing with the preamplifier test pulse and LED light pulser are used to verify that each channel is alive and that all five scintillator tiles are functional.

WORK STATEMENT:

- Connection of power, bias cables, communication, and signal cables to preamplifiers, and connection to one or more test racks of electronics.
- Measurement of bias current and debugging of any mis-connected photodetectors or light leaks.
- Measurement of LED pulses from each channel
- Setup of trigger counters for cosmic ray testing.
- Collection of cosmic ray data from all channels.
- Data logging and record keeping for each module.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	E. Mannel

4. WBS Element Code	5. WBS Element Title
1.07.01	Calorimeter Electronics Oversight and Management

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on subsystem engineer with 10% of time spent on project management.

TECHNICAL SCOPE:

Level 2 Engineer overseeing and managing the design, prototyping and production of EMCal and HCal front end and back end electronics. Responsibilities include budgeting, preparation of reports and presentations.

WORK STATEMENT:

Provide management and oversight of the design, prototyping and production of the electronics for the sPHENIX EMCal and HCal electronics. Specific tasks include:

6. Produce and monitor overall schedule for all aspects of the design, prototyping and production of the sPHENIX EMCal and HCal electronics to make sure that all milestones are met on schedule.
7. Provide overall management of procurement activities and monitoring of expenditures for the sPHENIX EMCal and HCal electronics
8. Work with scientific and engineering staff to produce all technical design documents. Review documentation to make sure that the design will achieve the performance needed to meet the scientific goals of sPHENIX.
9. Participate in project reviews:
    a. Assist with producing review documents.
    b. Make presentations at project reviews when requested.
10. Organize and schedule technical design, prototype performance and production readiness reviews for the sPHENIX EMCal and HCal electronics.

1. Project Title:	2. Date:	3: Person Responsible

SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.01	EMCal Sensor Specification

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for a scientist (25% time) and engineer (50% time) to test, evaluate and write design specification documents. Labor cost for technician (25% time) to help with assembly of test equipment and conducting tests. Material costs for purchasing sample optical sensors for testing and components needed for test fixtures.

TECHNICAL SCOPE:

Scientist and engineer to review and test potential optical sensors and select the sensor that meets the measurement requirements for the EMCal. Write design specification document to be used for the purchase of the optical sensors.

WORK STATEMENT:

This task covers the specification of the optical sensors to be used for the sPHENIX EMCal. Work includes:

9. Write design requirement document for the sPHENIX EMCal optical sensors.
10. Review potential commercial optical sensors that meet the general design requirements of the sPHENIX EMCal
11. Procure sample sensors for detailed evaluation to confirm that they meet the design requirements as defined in the design specification documents.
12. Design and execute tests to evaluate the performance of potential optical sensors for the sPHENIX EMCal.

Deliverables are design specification documents to be used for the purchase of prototype and production optical sensors for the EMCal.

1. Project Title:	2. Date:	3: Person Responsible

SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.02	EMCal Sensor Procurement

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are based on an engineer working 10 to 25% of time obtaining quotes, submitting purchase requisitions, monitoring delivery and overseeing testing of prototype and production sensors. Technician time for setting up and testing of prototype (50%) and production (25%) sensors. Student time at 100% for testing of production sensors.

TECHNICAL SCOPE:

Engineer to manage the procurement and testing of optical sensors needed for all prototypes and production of the EMCal. Technician to assist with setting up and testing optical sensors for prototypes and production EMCal detectors. Students to assist in the testing and sorting of production sensors for the EMCal.

WORK STATEMENT:

This task covers the procurement and Q/A testing of all optical sensors for the EMCal:

1. Obtain quotes for EMCal optical sensors for all prototyping stages and production.
2. Submit orders for EMCal optical sensors for all prototyping stages and production.
3. Monitor delivery of EMCal optical sensors.
4. Design test procedures for Q/A acceptance.
5. Test SiPMs for Q/A acceptance and sort production sensors based on performance criteria.

Deliverables are optical sensors for prototype EMCal electronics testing and production EMCal electronics.

1. Project Title:	2. Date:	3: Person Responsible

SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.03	HCal Sensor Specification

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for a scientist (25% time) and engineer (50% time) to test, evaluate and write design specification documents. Labor cost for technician (25% time) to help with assembly of test equipment and conducting tests. Material costs for purchasing sample optical sensors for testing and components needed for test fixtures.

TECHNICAL SCOPE:

Scientist and engineer to review and test potential optical sensors and select the sensor that meets the measurement requirements for the HCal. Based on the evaluation testing, write design specification document to be used for the purchase of the optical sensors.

WORK STATEMENT:

This task covers the specification of the optical sensors to be used for the sPHENIX HCal. Work includes:

1. Write design requirement document for the sPHENIX HCal optical sensors.
2. Review potential commercial optical sensors that meet the general design requirements of the sPHENIX HCal
3. Procure sample sensors for detailed evaluation to confirm that they meet the design requirements as defined in the design specification documents.
4. Design and execute tests to evaluate the performance of potential optical sensors for the sPHENIX HCal.

Deliverables are design specification documents to be used for the purchase of prototype and production optical sensors for the HCal.

1. Project Title:	2. Date:	3: Person Responsible

SPHENIX	1/21/14	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.04	HCal Sensor Procurement

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are based on an engineer working 10 to 25% of time obtaining quotes, submitting purchase requisitions, monitoring delivery and overseeing testing of prototype and production sensors. Technician time for setting up and testing of prototype (50%) and production (25%) sensors. Student time at 100% for testing of production sensors.

TECHNICAL SCOPE:

Engineer to manage the procurement and testing of optical sensors needed for all prototypes and production of the HCal. Technician to assist with setting up and testing optical sensors for prototypes and production HCal detectors. Students to assist in the testing and sorting of production sensors for the HCal.

WORK STATEMENT:

This task covers the procurement and Q/A testing of all optical sensors for the HCal:

1. Obtain quotes for HCal optical sensors for all prototyping stages and production.
2. Submit orders for HCal optical sensors for all prototyping stages and production.
3. Monitor delivery of HCal optical sensors.
4. Design test procedures for Q/A acceptance.
5. Test SiPMs for Q/A acceptance and sort production sensors based on performance criteria.

Deliverables are optical sensors for prototype HCal electronics testing and production HCal electronics.

1. Project Title:	2. Date:	3: Person Responsible

SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.01	EMCal On Detector Electronics Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor only. Scientist at 25%, engineer at 10% to 25%, and designer at 50%

TECHNICAL SCOPE:

Scientist, engineers and designers to specify, design and layout the on-detector prototype and production electronics for the EMCal detector. Work covers the specification, design, and layout of the preamplifier, EMCal mother board, EMCal control board, power systems, and signal and power cables

WORK STATEMENT:

This WBS item covers all aspects of the on-detector electronics design and layout for all prototypes and production systems for the EMCal. Specific tasks include:

1. Writing overall design documents and updating design documents based on testing of prototype systems.
2. Designing ground plan for EMCal electronics.
3. Design of preamplifier circuits for the EMCal
4. Design and layout of EMCal mother boards and EMCal control boards
5. Selection of components taking into consideration radiation tolerances and magnetic field requirements.
6. Review design documents at each stage prior to submission for fabrication.
7. Design of power systems, including working on cable routing plan in conjunction with mechanical design of the EMCal and support structure.
8. Provide estimate of heat load and cooling requirements for detector design
9. Review performance of prototype stages, write design specification changes documents, and update design documents after each prototype stages.
10. Provide necessary documents and drawings, and participate in reviews as required.

Deliverables are:

1. Design documents (schematics, layout files, component specifications, and bill of materials required for all prototype stages and production stages of the EMCal electronics development including power systems and cables.
2. Estimated heat and power loads for EMCal electronics
3. Grounding plan for EMCal detector
4. Cable plan for EMCal detector.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.02.01	EMCal On Detector Electronic: Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and writing design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the EMCal prototype v1.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the EMCal prototype v1. Results of the testing will provide input to design changes for the EMCal frontend prototype v2 electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the EMCal Prototype v1 electronics. Production covers the procurement of components necessary for 6 64-channel motherboards, including daughter cards, power supplies and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources. Tests include, but are not limited to, testing the dynamic range, cross talk, signal integrity, performance of the temperature compensation circuit, and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the EMCal Prototype v2 electronics. Measurements of the power and heat loads of the circuits will be made and used to make preliminary estimates of the cooling requirements.

Deliverables include a full EMCal prototype v1, prototype test result documents and design specification changes for EMCal prototype v2.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.02.02	EMCal On Detector Electronic: Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and writing design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the EMCal prototype v2.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the EMCal prototype v2. Results of the testing will provide input to design changes for the EMCal frontend preproduction prototype electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the EMCal Prototype v2 electronics. Production covers the procurement of components necessary for six 64-channel motherboards, including daughter cards, power supplies, cables and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources and includes testing with the Digitize Prototype v2 if available. Tests include, but are not limited to, testing the dynamic range, cross talk, signal integrity, performance of temperature compensation circuit, and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the EMCal Production Prototype electronics. Measurements of the power and heat loads of the circuits will be made and used to update the cooling requirements.

Deliverables include a full EMCal prototype v2, prototype test result documents and design specification changes for EMCal preproduction prototype.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.02.03	EMCal On Detector Electronics: Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and writing design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the EMCal preproduction prototype.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the EMCal preproduction prototype. Results of the testing will provide input to design changes for the EMCal frontend production electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the EMCal Pre-Production Prototype electronics. Prior to fabrication an electrical safety review will be conducted to insure that the pre-production design meets the BNL CA-D electrical safety requirements. Any changes required to meet BNL CA-D safety requirements will be incorporated into the preproduction design before fabrication and assembly. Fabrication and assembly covers the procurement of components necessary for six 64-channel motherboards, including daughter cards, power supplies and cables. Testing is full chain test of the on-detector electronics mounts on the pre-production EMCal prototype and readout with the preproduction digitizer electronics at a test beam. Tests include, but are not limited to: testing dynamic range, cross talk, signal integrity, performance of the temperature compensation circuit, power distribution, hardware mounting, and cable routing. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the EMCal production electronics. Measurements of the power and heat loads of the circuits will be made and used to

finalize the cooling requirements.

Deliverables include a full EMCal preproduction prototype, prototype test result documents, design specification changes for EMCal production electronics, and final heat and power load estimates.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.03	EMCal On Detector Electronics Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are for: Engineer to oversee and manage procurement of all components (10%), fabrication of all electronics boards (10%), and assembling and testing of all electronics (25%). Technician to procure of all components (10%), oversee fabrication of all electronics boards (10%), and oversee and assist with the final assembly and testing of all electronics (25%). Students to assist with final assembly and testing (100%). Material costs are for all components needed for the full production of EMCal electronics. Component costs are based on costs of similar boards. Board assembly is assumed to be done by a commercial assembly company. Total costs for the total number of boards required for the final detector and do not include spares. A 10% yield loss is assumed.

TECHNICAL SCOPE:

This WBS items covers the production of the front end electronics required for the full EMCal. Major components include the EMCal mother boards with preamps, daughter boards with temperature compensation circuitry, interface boards, controller boards, power system (low voltage and bias) and all power and signal cables required for the final design.

WORK STATEMENT:

This WBS item covers the full procurement, fabrication, assembly, and testing of the all frontend electronics required for the sPHENIX EMCal. Prior to procurement a final readiness review of the final design will be performed to insure that the production design meets the design requirements for the sPHENIX EMCal detector. Procurement covers the process of obtaining quotes for all components needed for production, placing purchase requisitions, tracking orders, and Q/A of delivered

components. Fabrication covers obtaining quotes for assembly of major boards, placing purchase requisitions for board assembly, tracking assembly, working with assembly house to address any assembly issues that might arise, and Q/A of delivered boards. The assembly stages includes the assembly of final modules for testing and delivery for installation into the EMCal.

The deliverables are full tested frontend electronics, power supplies and cables for installation into the sPHENIX EMCal.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.04	HCal On Detector Electronics Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor only. Scientist at 25% to 50%, engineer at 10% to 50%, and designer at 50%

TECHNICAL SCOPE:

Scientist, engineers and designers to specify, design and layout the on-detector prototypes (v1, v2 and preproduction) and production electronics for the HCal detector. Work covers the specification, design, and layout of the HCal preamplifier board, HCal controller board, power systems, and signal and power cables

WORK STATEMENT:

This WBS item covers all aspects of the on-detector electronics design and layout for all prototypes and production systems for the HCal. Specific tasks include:

1. Writing overall design documents and updating design documents based on testing of prototype systems.
2. Designing ground plan for HCal electronics.
3. Design of preamplifier circuits for the HCal
4. Design and layout of HCal control boards
5. Selection of components taking into consideration radiation tolerances and magnetic field requirements.
6. Review design documents at each stage prior to submission for fabrication.
7. Design of power systems, including working on cable routing plan in conjunction with mechanical design of the HCal and support structure.
8. Provide preliminary estimate of heat load and cooling requirements for detector design
9. Review performance of prototype stages, write design specification changes

documents, and update design documents after each prototype stages.

10. Provide necessary documents and drawings, and participate in reviews as required.

Deliverables are:

1. Design documents (schematics, layout files, component specifications, and bill of materials required for all prototype stages and production stages of the HCal electronics development including power systems and cables.
2. Estimated heat and power loads for HCal electronics
3. Grounding plan for HCal detector
4. Cable plan for HCal detector.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.05.01	HCal On Detector Electronic: Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and write design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the HCal prototype v1.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the HCal prototype v1. Results of the testing will provide input to design changes for the HCal prototype v2 frontend electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the HCal Prototype v1 electronics. Production covers the procurement of components necessary for a 32 of HCal Preamplifiers (16 inner HCal, 16 Outer HCal), including controller boards, power supplies and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources. Tests include, but are not limited to, testing dynamic range, cross talk, signal integrity, performance of temperature compensation, and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the HCal Prototype v2 electronics. Measurements of the power and heat loads of the circuits will be made and used to make preliminary estimates of the cooling requirements.

Deliverables include a full HCal prototype v1, prototype test result documents and design specification changes for HCal prototype v2.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	1/21/14	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.05.02	HCal On Detector Electronic: Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and write design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the HCal prototype v2.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the HCal prototype v2. Results of the testing will provide input to design changes for the HCal frontend preproduction prototype electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the HCal Prototype v2 electronics. Production covers the procurement of components necessary for a 32 of HCal Preamplifiers (16 inner HCal, 16 Outer HCal), including controller boards, power supplies and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources. Tests include, but are not limited to, testing dynamic range, cross talk, signal integrity, performance of temperature compensation and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the HCal Pre-Prototype electronics. Measurements of the power and heat loads of the circuits will be made and used to update the cooling requirements.

Deliverables include a full HCal prototype v2, prototype test result documents and design specification changes for HCal preproduction prototype

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.05.03	HCal On Detector Electronics: Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and write design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the HCal preproduction prototype.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the HCal preproduction prototype. Results of the testing will provide input to design changes for the HCal frontend production electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the HCal Pre-Production Prototype electronics. Prior to fabrication an electrical safety review will be conducted to insure that the pre-production design meets the BNL CA-D electrical safety requirements. Any changes required to meet BNL CA-D safety requirements will be incorporated into the preproduction design before fabrication and assembly. Fabrication and assembly covers the procurement of components necessary for a 32 HCal channels (16 inner HCal and 16 outer HCal), including daughter card, power supplies and test fixtures. Testing is full chain test of the on-detector electronics mounts on the pre-production HCal prototype and readout with the preproduction digitizer electronics at a test beam. Tests include, but are not limited to, testing: dynamic range, cross talk, signal integrity, performance of the temperature compensation circuit and power distribution, hardware mounting and cable routing. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the HCal production

electronics. Measurements of the power and heat loads of the circuits will be made and used to finalize the cooling requirements.

Deliverables include a full HCal preproduction prototype, prototype test result documents, design specification changes for HCal production electronics, and final heat and power load estimates.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.06	HCal On Detector Electronics Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are for: Engineer to oversee and manage procurement of all components (10%), fabrication of all electronics boards (10%), and assembling and testing of all electronics (25%). Technician to procure of all components (10%), oversee fabrication of all electronics boards (10%), and oversee and assist with the final assembly and testing of all electronics (25%). Students to assist with final assembly and testing (100%). Material costs are for all components needed for the full production of HCal electronics. Component costs are based on costs of similar boards. Board assembly is assumed to be done by a commercial assembly company. Total costs for the total number of boards required for the final detector and do not include spares. A 10% yield loss is assumed.

TECHNICAL SCOPE:

This WBS items covers the production for all front end electronics required for the full HCal. Major components include the HCal preamps, HCal interface boards, HCal controller boards, power system (low voltage and bias) and all power and signal cables required for the final design.

WORK STATEMENT:

This WBS item covers the full procurement, fabrication, assembly, and testing of the all frontend electronics required for the sPHENIX HCal. Prior to procurement a final readiness review of the final design will be performed to insure that the production design meets the design requirements for the sPHENIX HCal detector. Procurement covers the process of obtaining quotes for all components needed for production, placing purchase requisitions, tracking orders, and Q/A of delivered components. Fabrication covers obtaining quotes for assembly of major boards,

placing purchase requisitions for board assembly, tracking assembly, working with assembly house to address any assembly issues that might arise, and Q/A of delivered boards. The assembly stage includes the assembly of final modules for testing and delivery for installation into the HCal.

The deliverables are fully tested frontend electronics, power supplies and cables for installation into the sPHENIX HCal.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.01	Calorimeter Digitizer Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only: Scientist to write design specifications and review prototype test results (10%). Engineer to assist with design specification (50%), select components and generate schematic design files to meet the design specifications (50%) and review final layout files (10%). Designer to layout electronics boards based schematics and design specifications (50%).

TECHNICAL SCOPE:

This WBS item covers the writing of design specification, component selection, schematic design, PCB board layout out, and FPGA code development for all components need for the digitizers for the HCal and EMCal. Major modules are: XMIT module, Clock Master, Digitizer Boards, crates and backplanes, and power systems. Work covers all prototypes (v1, v2, preproduction) and production boards.

WORK STATEMENT:

This WBS item covers all design stages of the sPHENIX calorimeter digitizer system. Design work includes: writing and updating design specifications for the prototype and production stages, producing complete schematics and layout files for all boards comprising the digitizer system, specifying components, producing bill of material documents for component procurement, specifying and designing power systems and cables.

Deliverables are all design documents (specifications, schematics, bill of materials) needed for prototype and production fabrication, FPGA code, crate and power system design specifications, and cable specification for power and Digitizer-to-DCM signals.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.02.01	Calorimeter Digitizer Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v1, and write design change specifications for prototype v2 (25%). Engineer to assemble, test and write design change specifications (25%). Technician to oversee procurement of components, assembly of all PCB boards (10%), and assist with final assembly and testing of prototype v1 electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing and writing design change specifications for 384 channel digitizer prototype v1. Test results will be used for writing design change specifications for the prototype v2 digitizer electronics

WORK STATEMENT:

This WBS items covers the assembly of a 384-channel digitizer prototype v1. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v1 prototype. Bench testing includes testing of frontend digitizers, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to estimate cooling requirements for the digitizer racks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional 384 channel prototype v1, design change specifications for prototype v2, and estimated power and heat loads for the

digitizer system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.02.02	Calorimeter Digitizer Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v2, and write design change specifications for preproduction prototype (25%). Engineer to assemble, test and write design change specifications (25%). Technician to oversee procurement of components, assembly of all PCB boards (10%), and assist with final assembly and testing of prototype v2 electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing of a 384-channel digitizer prototype v2. Test results will be used for writing design change specifications for the preproduction prototype digitizer electronics

WORK STATEMENT:

This WBS items covers the assembly of a 384-channel digitizer prototype v2. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v2 prototype. Bench testing includes testing of frontend digitizers, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to estimate cooling requirements for the digitizer racks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional 384 channel prototype v2, design change specifications for preproduction prototype, and estimated power and heat loads for the digitizer system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.02.03	Calorimeter Digitizer Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of preproduction prototype, and write design change specifications for production (25%). Engineer to assemble, test and write design change specifications (25%). Technician to oversee procurement of components, assembly of all PCB boards (10%), and assist with final assembly and testing of the preproduction prototype electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, and testing change for a 384-channel digitizer preproduction prototype. Test results will be used for writing design change specifications for the production digitizer electronics

WORK STATEMENT:

This WBS items covers the assembly of a 384-channel digitizer preproduction prototype. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the preproduction prototype. The testing is to be done as part of a full system chain test including preproduction EMCal and HCal detectors, preproduction EMCal and HCal frontend electronics and DCM readout. Testing includes testing of frontend digitizers, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to determine cooling requirements for the digitizer racks. Design specification changes are written based on chain tests.

Deliverables include: Fully functional 384 channel preproduction prototype, design change specifications for production prototype, and final power and heat loads for the digitizer system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.03	Calorimeter Digitizer Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost: Scientist to review final design specifications (50%) and test results of production electronics (25%). Engineer to oversee and manage the procurement of all components, PCB board fabrication and final assembly of production digitizer system for the EMCal and HCal. Designer to assist with final design review and modifications for production (25%). Technician for procurement of components and detailed oversight of board fabrication (10%) and work on final assembly of production electronics (25%). Material cost include: the cost for 27392 channels of digitizers (64 channels per board), 28 Controller boards, 28 XMIT boards, 28 crates and associated power supplies. Production costs assume that commercial vendor is used for all PCB board fabrication. Project engineers and technicians do final system assembly and testing. Component cost includes a 10% loss due to yield. No spare modules are included the cost.

TECHNICAL SCOPE:

This WBS item includes the procurement of all components, final assembly and testing of the production electronics for the EMCal and HCal. There are a total of 384 64-channel digitizer boards for the EMCal located in 24 crates. Each crate has 1 controller board and 1 XMIT board. There are a total of 44 64-channel digitizer boards for the HCal located in 4 crates, with each crate having a controller board and XMIT board.

WORK STATEMENT:

This WBS item covers the full production of the digitizer system for the sPHENIX calorimeters. Prior to start of production, a readiness review is to be conducted to insure that the system meets the design requirements for the sPHENIX calorimeter digitizer system. The procurement process includes obtaining quotes for all

components necessary for the digitizer system, placing purchase requisitions for components, tracking deliver of components and Q/A of delivered components. The fabrication and assembly stage covers the assembly of all PC boards required for the digitizer system, assembly of crates and power supplies and installation of system boards into crates for testing. The testing stage covers the testing 24 fully assembled crates for the sPHENIX EMCal and 4 crates for the sPHENIX HCal detectors

Deliverables: 28 crates of fully tested digitizers, associated power supplies and cables for installation into the sPHENIX detector.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	C Y Chi

4. WBS Element Code	5. WBS Element Title
1.08.01	Project Oversight and Management

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on subsystem engineer with 10% of time spent on project management.

TECHNICAL SCOPE:

Level 2 engineer overseeing and managing the design, prototyping and production of the sPHENIX DAQ and Trigger systems. Responsibilities include budgeting, preparation of reports and presentations.

WORK STATEMENT:

Provide management and oversight of the design, prototyping and production of the electronics for the sPHENIX DAQ and Trigger Systems. Specific tasks include:

1) Produce and monitor overall schedule for all aspects of the design, prototyping and production of the sPHENIX DAQ and trigger systems to make sure that all milestones are met on schedule.
2) Provide overall management of procurement activities and monitoring of expenditures for the sPHENIX DAQ and Trigger systems.
3) Work with scientific and engineering staff to produce all technical design documents. Review documentation to make sure that the design will achieve the performance needed to meet the scientific goals of sPHENIX.
4) Participate in project reviews:
    a) Assist with producing review documents.
    b) Make presentations at project reviews when requested.

Organize and schedule technical design, prototype performance and production readiness reviews for the sPHENIX DAQ and Trigger systems.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	M. Purschke

4. WBS Element Code	5. WBS Element Title
1.08.02.01	DAQ Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor: Labor cost only, no material. Labor is based on a scientist and an engineer working approximately 18% each on the design.

TECHNICAL SCOPE:

Scientist and level-2 engineer will work together and manage the required phases of work, including documentation, reports, presentations, and budgeting.

WORK STATEMENT:

1) As early as possible, a DAQ prototype is needed to let other scientists and groups test their equipment in a standard environment. Ideally, the prototype is on an evolutionary path toward the final sPHENIX DAQ design so the components can already be tested and debugged, and other members can gain experience with the implementation. The scientist and level 2 engineer will evaluate existing designs and implementations and determine a) which aspects can be re-used in the prototype, b) which can be modified to meet the requirements, and c) what needs to be developed new.

2) The front-end layout needs to be specified w.r.t. granularity and the number of DAQ components such as DCMs, JSEBs., and Partitioners.

3) based on 2), calculate the required number of boards and spares, the number of crates and power requirements, and the amount of rack space.

4) The existing Event Builder will likely require a number of design changes in order to

satisfy the requirements of the sPHENIX DAQ system. Scientist and engineer will evaluate the existing design and identify areas which need to be modified. Based on those findings, determine the right computer types to satisfy the rate requirements.

5) Once 2) through 4) are completed, a review of the overall design will be performed.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	M. Purschke

4. WBS Element Code	5. WBS Element Title
1.08.02.02	DAQ Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

The overall cost is determined by labor costs (scientist (32 days), level-2 engineer (32 days), and a technician (15 days)), and material costs of $22,000.

TECHNICAL SCOPE:

Scientist and level-2 engineer will manage the required phases of work, including documentation, reports, presentations, budgeting, and procurement.

WORK STATEMENT:

A DAQ prototype will consist of several computers, and network switch, and storage. We envision to have more than one copy of the prototype in order to support other groups with their development work, in addition to one copy used for the current development work by the scientist and engineer. The technician is expected to perform the installation, mounting and cabling of equipment, in addition to the installation of firmware, where applicable.

1) Scientist and engineer will specify and select the computers and network switches, and procure the hardware

2) The initial setup of the computers and network equipment will be performed by the scientist and engineer. Once the right configuration is chosen, setting up more systems becomes part of the installation.

3) At this point, the software development laid out in 1.08.02.01 begins.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	M. Purschke

4. WBS Element Code	5. WBS Element Title
1.08.02.03	DAQ Production

6.. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

The over cost consists of labor costs and material / procurement.

TECHNICAL SCOPE:

Scientists, level-2 engineers and students will work together and manage the required phases of work, including documentation, reports, presentations, budgeting, and procurement.

WORK STATEMENT:

This element details the most important parts of the DAQ production.

1) the various detector-specific front-end boards will see their final minor design changes and board layout;

2) the required number of boards and spares will be produced;

3) most boards will require small customizations to the general firmware.

4) At this stage the required number of crates is firmly known. The crates can be procured and installed.

5) The SEB and ATP computers can be procured, as well as new bufferboxes.

6) At this point, a number of revisions to the event builder software, some of which will have been tested in the DAQ prototype already, can be implemented, debugged, and finalized.

7) The main network switch needs to be selected and procured. Although it is unlikely

that a radically new technology will be chosen, this has to be closely coordinated with step 5) in order to avoid incompatibilities in network technologies.

8) The switch has to be installed, set up, and tuned.

9) The links between the switches, presumably fibers, will have to be connected.

10) The machines (SEBs, ATPs, and Bufferboxes) will have their operating system installed, and their setup finalized.

11) Final testing, debugging will be performed, and potential minor new required features will be implemented.

12) Fake data will be sent through the DAQ system to test the individual components, and the data monitoring framework will be debugged and finalized.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	J. Haggerty

4. WBS Element Code	5. WBS Element Title
1.08.03.01	Trigger Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only: Scientist to write design specifications, review prototype tests and write design change specifications for trigger system (25%). Engineer to assist writing design specifications (25%), produce schematics (50%), oversee board layout (10%), and write FPGA Code (25%). Designer to layout trigger board (50%)

TECHNICAL SCOPE:

This WBS item covers the design of the prototype and production trigger system. Design work includes writing trigger specifications, generating schematics for all electronics, laying out any PCBs required for the trigger system, designing and writing all FPGA code requires, and reviewing prototype performance tests results.

WORK STATEMENT:

This WBS item covers the overall design of prototype and production electronics for the sPHENIX trigger systems. Specific tasks include:

1. Writing trigger system design specifications
2. Generating electronics schematics for all boards required for the trigger systems for prototype and production rounds
3. Laying out for production all boards required for the trigger system prototype and production rounds.
4. Specifying cables (power/signal) needed for the trigger prototype and production rounds
5. Specifying and designing crates and power systems for trigger prototype and production rounds.
6. Specifying and writing FPGA code necessary for trigger prototyping and production systems
7. Specifying and designing test procedures to verify performance of trigger prototype and production rounds

8. Reviewing performance of prototype production rounds and writing design changes based on test results.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	J. Lajoie

4. WBS Element Code	5. WBS Element Title
1.08.03.02.01	Trigger Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor: Scientist to oversee system assembly, testing, review performance and write design specification changes (25%) for the prototype v1 trigger system. Engineer to provide oversight of the procurement, fabrication and assembly of the prototype v1 trigger system (10%) and to assemble, test and review the performance of the prototype v1 trigger system (25%). Technician to procure all components, oversee fabrication of trigger modules (10%), and assist with the assembly of the prototype v1 trigger system (25%).

TECHNICAL SCOPE:

This WBS item covers the production and testing on the prototype v1 trigger system. Work covers the procurement of all components, fabrication of any electronics modules, testing and reviewing of the performance of the prototype v1 trigger system.

WORK STATEMENT:

This WBS item covers the first prototype trigger. Specific tasks include:

1. Obtaining quotes, placing orders and tracking the orders for all components needed for the trigger prototype
2. Obtaining quotes, placing orders and tracking the production and assembly of trigger boards needed for prototype.
3. Assembling the prototype trigger system
4. Testing the prototype trigger system and writing design specifications based on performance of the prototype trigger system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	J. Lajoie

4. WBS Element Code	5. WBS Element Title
1.08.03.02.02	Trigger Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor: Scientist to oversee system assembly, testing, review performance and write design specification changes (25%) for the preproductionprototype trigger system. Engineer to provide oversight of the procurement, fabrication and assembly of the trigger system (10%) and to assemble, test and review the performance of the preproduction prototype trigger system (25%). Technician to procure all components, oversee fabrication of trigger modules (10%), and assist with the assembly of the preproduction prototype trigger system (25%).

TECHNICAL SCOPE:

This WBS item covers the production and testing on the preproduction prototype trigger system. Work covers the procurement of all components, fabrication of any electronics modules, testing and reviewing of the performance of the preproduction prototype trigger system.

WORK STATEMENT:

This WBS item covers the preproduction prototype trigger. Specific tasks include:

1. Obtaining quotes, placing orders and tracking the orders for all components needed for the trigger preproduction prototype.
2. Obtaining quotes, placing orders and tracking the production and assembly of trigger boards needed for preproduction prototype.
3. Assembling the preproduction prototype trigger system.
4. Testing the preproduction prototype trigger system and writing design specifications based on performance of the preproduction prototype trigger system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/20/2015	J. Lajoie

4. WBS Element Code	5. WBS Element Title
1.08.03.03	Trigger Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor: Scientist to oversee system assembly, testing, review performance and write design specification changes (25%) for the production trigger system. Engineer to provide oversight of the procurement, fabrication and assembly of the production trigger system (10%) and to assemble, test and review the performance of the production trigger system (25%). Technician to procure all components, oversee fabrication of trigger modules (10%), and assist with the assembly of the production trigger system (25%).

TECHNICAL SCOPE:

This WBS item covers the production and testing on the production trigger system. Work covers the procurement of all components, fabrication of any electronics modules, testing and reviewing of the performance of the production trigger system.

WORK STATEMENT:

This WBS item covers the preproduction prototype trigger. Specific tasks include:

1. Obtaining quotes, placing orders and tracking the orders for all components needed for the trigger production.
2. Obtaining quotes, placing orders and tracking the production and assembly of trigger boards needed for production.
3. Assembling the production trigger system
4. Testing the production trigger system

SPHENIX	01/15/2015	P. Giannotti

4. WBS Element Code	5. WBS Element Title
1.09.01 Infrastructure	Project Management and Oversight

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on Subsystem scientist with 10% of time and subsystem engineer 50% time spent on project management of this task.

TECHNICAL SCOPE:

Level 2 engineer & scientist overseeing and managing the infrastructure work, including presentations, reports, budgeting, etc.

WORK STATEMENT:

Manage and guide the scientific and engineering management of sPHENIX infrastructure tasks, including:

1. Monitoring and scheduling progress towards evaluating existing PHENIX infrastructure and determining which aspects of PHENIX infrastructure (a) will be utilized on sPHENIX without modification, (b) will modified from PHENIX configuration to sPHENIX specific requirements (c) will not be needed at all for sPHENIX and determining what new infrastructure items will be needed for sPHENIX.

2. Supervising and managing the design of new sPHENIX Infrastructure items and the design of modifications to existing PHENIX infrastructure.

3. Supervising and managing the production of new sPHENIX Infrastructure items and the production of modifications to existing PHENIX infrastructure.

Notes:

5. Decommissioning and disposition of existing PHENIX infrastructure is covered in WBS Item 1.02.
6. Assembly and Installation of new sPHENIX infrastructure is covered in WBS Item 1.10

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	P. Giannotti

4. WBS Element Code	5. WBS Element Title
1.09.02 Installation	Infrastructure System Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

All costs in this item are labor based, no material costs. All labor costs are based on engineering estimates for scientific, engineering and other technical professionals contributing to the design and documentation associated with the technical items listed below.

TECHNICAL SCOPE:

This item includes all tasks required to specify and design the following sPHENIX infrastructure items:

a. Mechanical support structures (those structural components of the sPHENIX detector which integrate and provide structural support the various detector subsystems that comprise the sPHENIX detector, including the central support pedestal carriage base, base to HCal support, base to bridge support, bridge, mid platform, Inner HCal to outer HCal support rings, tracking support, flux return end caps and magnet support mounting and associated alignment features)

b. AC Line Electric Power distribution design

c. Cryogenics Supply Support Design (Note: this includes only structural support for routing of cryo supply. Actual cryo transfer lines and all associated plumbing and control hardware are part of the Magnet WBS item #1.03)

d. Beampipe/Vacuum Design

e. IR HVAC Design

f. IR Electronics Cooling Water Design

g. Safety Subsystems Design

h. Detector Support Services Systems Design

i. Detector Support Services Systems Design

j. Non -IR Infrastructure Design

WORK STATEMENT:

The efforts required to complete this WBS item are described for the various subtasks as follows:

Mechanical Support Structures Design - This task encompasses design of IR modifications and structural supports for the sPHENIX magnet cryo transfer line. All detailed tasks involving the design of piping, valves, cryo storage, instrumentation and control of LHe and/or LN2 to sPHENIX SC Magnet are described under the Magnet WBS details.

Deliverables: drawings: estimated 8 assembly, 57 detail, 1 outline/interface, 1 layout and 1 envelope drawing.

AC Line Electric Power Distribution Design- This encompasses all detailed tasks involving evaluation of the following items:

1) Three phase 480/208 volt and 208/120 volt distribution circuits.
2) New/modified or repurposed power transformers, cable trays, and circuit breaker distribution panels.
3) Emergency power requirements from the backup diesel generator.
4) Uninterruptible Power System (UPS) requirements.

Deliverables: drawings: estimated 5 schematics.

Cryogenics Supply Support Design – This task encompasses all detailed tasks required for design of the liquid helium refrigeration system supplying the sPHENIX superconducting magnet. Designs for individual cryogenic equipment including pre-cool down LN2 dewars with associated fill equipment and liquid helium transfer lines from the RHIC magnet cooling system.

Deliverables: drawings: estimated 1 schematic and 20 detail drawings.

Beampipe/Vacuum Design - This task encompasses all detailed tasks involving the evaluation of existing beampipe equipment and the design of new/modified/repurposed beampipe sections, beampipe supports throughout the IR, vacuum valves, pumps, controls, etc.

Deliverables: drawings: estimated 4 assembly, 1 schematic, 5 detail drawings

IR HVAC Design - This task encompasses all detailed tasks involving the evaluation of existing IR & counting house environmental control systems and the design and specification of new/modified repurposed HVAC equipment including air conditioning units (air handlers and compressor/condensers), thermostatic

controls, humidity control, etc.

Deliverables: drawing: estimated 1 schematic/layout drawing

IR Electronics Cooling Water Design - This task encompasses all detailed tasks involving the evaluation of the existing PHENIX experimental cooling water supply, distribution and monitoring for electronics racks and support sub systems requiring water cooling, and the specification and design of new/modified and or re-purposed electronics water cooling services.

Deliverables: drawings: estimated 1 schematic, 3 detail/subassembly drawings

Safety Subsystems Design- This task encompasses all detailed tasks involving the evaluation of the existing PHENIX fire detection & suppression, HSSD, Water leak detection, ODH, monitoring, interlocks, alarms, PASS system integration, and the specification and design of new/modified and or re-purposed equipment for these safety systems.

Deliverables: drawings: estimated 4 schematic

Detector Support Services Systems Design - This task encompasses all detailed tasks involving the specification and design of detector support services including Monitoring and control cable routing and management, fibers, cooling lines, etc., including cable trays, mounting hardware etc., racks and in-rack support services (e.g. fan trays), dry air, experimental gases, N2 and shop air.

Deliverables: drawings: estimated 10 schematic drawings

Detector Access Design - This task encompasses all detailed tasks involving the specification and design of platforms, stairways, walkways, including access control, safety barriers etc.

Deliverables: drawings: estimated 4 assembly, 2 schematic, 5 detail/layout drawings

Non -IR Infrastructure - This task encompasses all detailed tasks involving the specification and design of changes, upgrades and improvements for existing PHENIX Rack Room, Control Room, Gas Pad, etc. as needed to efficiently and effectively support sPHENIX

Deliverables: drawings: estimated 4 schematics, 5 detail drawings

Each of these subtopics includes design/safety reviews as necessary.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	P. Giannotti

4. WBS Element Code	5. WBS Element Title
1.09.03 Infrastructure	Infrastructure Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

The costs associated with this item are for both labor and materials. The labor is the effort by scientists, engineers, designers, technical staff and BNL trades associated with the procurement of material and equipment described in the infrastructure design WBS dictionary entry. All labor and material estimates for this are based on engineering estimates.

TECHNICAL SCOPE:

This item includes all tasks and costs required to procure material and equipment for the following sPHENIX infrastructure items

a. Mechanical support structures (those structural components of the sPHENIX detector which integrate and structural support the various detector subsystems that comprise the sPHENIX detector, including the Central support pedestal carriage base, base to HCal support, Base to bridge support, bridge, mid platform, Inner HCal to outer HCal support rings, Tracking support, flux return end caps and magnet support mounting and associated alignment features)

b. AC Line Electric Power Distribution Components

c. Cryogenics Supply Support (Note: this includes only structural support for routing of cryo supply. Actual cryo transfer lines and all associated plumbing and control hardware are part of the Magnet WBS item #1.03)

d. Beampipe/vacuum Components

e. IR HVAC Components

f. IR Electronics cooling water Components

g. Safety subsystems Components

h. Detector support services systems Components

i. Detector support services systems Components

j. Non -IR Infrastructure Components

WORK STATEMENT:

The efforts required to complete this WBS item are described for the various subtasks as follows:

Mechanical Support Structures Procurement - This task encompasses fabrication and procurement of all components of the central pedestal carriage, inter detector connecting hardware and support structures, including Central Pedestal Carriage componenst and hardware, Hillman rollers on central carriage, alignment hardware, hydraulic jacking hardware, Outer HCal cradle, Inner HCal to Outer HCal mounting ring, bridge platform supports, Magnet mounting and alignment provisions, Magnet stack support structure, and flux return end caps.

Deliverables: Central Pedestal Carriage componenst and hardware, Hillman rollers on central carriage, alignment hardware, hydraulic jacking hardware, Outer HCal cradle, Inner HCal to Outer HCal mounting ring, bridge platform supports, Magnet mounting and alignment provisions, Magnet stack support structure, and flux return end caps.

AC Line Electric Power Distribution Procurement - This task encompasses fabrication and procurement of all components required to upgrade the following:

1) Three phase 480/208 volt and 208/120 volt distribution circuits.
2) New/modified or repurposed power transformers, cable trays, and circuit breaker distribution panels.
3) Emergency power requirements from the backup diesel generator.
4) Uninterruptible Power System (UPS) requirements.

Deliverables: AC Line Electric Power Distribution Components

Cryogenics Supply Support Procurement - This task encompasses fabrication and procurement of all components and for IR modifications and structural supports for the sPHENIX magnet cryo transfer line. Cryo transfer line and related cryo components are described under the Magnet WBS details.)

Deliverables: Cryogenics supply support components

Beampipe/Vacuum Procurement - This task encompasses fabrication and procurement modifications and new components of the existing beampipe sections, beampipe supports throughout the IR, vacuum valves, pumps, controls, etc.

Deliverables: Beampipe/Vacuum: modification to existing components and new components

IR HVAC Procurement - This task encompasses fabrication and procurement of modifications and additions to components of the existing IR environmental control system including Air conditioning units (air handlers and compressor/condensers), thermostatic controls, humidity control, etc.

Deliverables: IR HVAC: modification to existing components and new components

IR Electronics Cooling Water Procurement - This task encompasses fabrication and procurement of modifications and additions to components of the existing PHENIX experimental cooling water supply, distribution and monitoring for electronics racks and support sub systems requiring water cooling.

Deliverables: IR Electronics Cooling Water: modification to existing components and new components

Safety Subsystems Procurement -. This task encompasses fabrication and procurement of modifications and additions to all components of the existing PHENIX fire detection & suppression, HSSD, Water leak detection, ODH, monitoring, interlocks, alarms, PASS system integration.

Deliverables: Safety Subsystems: modification to existing components and new components

Detector Support Services Systems Procurement - This task encompasses fabrication and procurement of all components of detector support services including cable routing and management, fibers, cooling lines, monitoring and control lines, etc., including cable trays, mounting hardware etc., racks and in-rack support services (e.g. fan trays), dry air, N2 and shop air.

Deliverables: Detector Support Services Systems: modification to existing components and new components

Detector Access Procurement - This task encompasses fabrication and procurement of all components of the of sPHENIX platforms, stairways, walkways, including access control, safety barriers etc.

Deliverables: Detector Access: modification to existing components and new components

Non -IR Infrastructure Procurement - This task encompasses fabrication and procurement of all services, equipment and components for changes, upgrades and improvements to existing PHENIX Rack Room, Control Room, Gas Pad, etc. as needed to efficiently and effectively support sPHENIX)

Deliverables: Non -IR Infrastructure: modification to existing components and new components

Note: (Assembly and installation of the above infrastructure components is not included in these estimates, see WBS 1.10 for assembly and installation details)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10	Installation and Integration

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description
COST CONTENT: Summary Item - Rolls up costs from WBS Items 1.10.01 through 1.10.03 TECHNICAL CONTENT: Includes Project Management and technical Coordination, Tooling, Fixtures and Procedures design, and assembly, installation and commissioning (in building 1008) of infrastructure and detector subsystem components. WORK STATEMENT: See Subtasks

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.01	Integration management and technical coordination of Assembly and Installation activities

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on engineering estimates of effort required to perform the tasks as described in this section.

TECHNICAL CONTENT:

This task includes all scientific, engineering and technical staff efforts to plan and supervise all aspects of the assembly, integration and installation of the sPHENIX infrastructure components (defined by WBS 1.09), completed and tested detector subsystem modules and electronics (defined by WBS 1.04 though 1.08), and sPHENIX superconducting solenoid magnet (defined by WBS 1.03) at 1008

WORK STATEMENT:

Supervise, guide the scientific and engineering management of sPHENIX assembly, integration and installation tasks and develop the associated plans for those same tasks as follows:

1. Subsystem Interface & Integration Plan - Plan to describe and define all interfaces between WBS subsystems, including detector mechanical interfaces, electrical interfaces, conduits and cable routing management, space allocation, cooling (water and air), detector cryogenic, inerting,

drying, etc. gas supply routing and interfaces.
Deliverable: written document, (note: related schematic drawings created in Infrastructure WBS item 1.09)

2. Subsystem Initial Envelope Drawing - Drawing to globally define space allocation for detector subsystems, infrastructure, support services and potential future additions.
   Deliverable: Drawing

3. Subsystem Final Envelope Drawing(s) - Drawing set of individual envelope drawings for each detector subsystem
   Deliverable: Drawings: estimated at 5 drawings

4. Cable Management Plan - Overall plan for routing electrical and optical, power, signal, control and monitoring cables between detectors to control racks, front end modules, patch panels, data acquisition, etc.
   Deliverable: written document

5. Survey Plan - Overall plan for alignment and positioning of overall detector relative to nominal beam orbit, individual detector subsystems to the overall detector, and internal alignment and positioning of detector subsystem internal components to the subsystem overall alignment.
   Deliverable: written document

6. Integration & Installation Review - Engineering and safety review of individual plans above.
   Deliverable: written report

7. Integration Supervision - Management and supervision effort to guide the project through all individual tasks and assure adherence to schedule and budget allotments.
   Deliverable: none

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.02	Integration/Installation Tooling/Fixture/Procedures Design and Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor and material costs for the design and production of Tooling, Fixtures and Procedures for the items listed in the technical content below. All costs are based on engineering estimates

TECHNICAL CONTENT:

Analyses, design and creation/fabrication/procurement of tooling, fixtures and procedures of the following items:

1. CP Carriage Integration/Installation
2. sPHENIX SC Magnet Integration/Installation
3. Outer HCal Integration/Installation
4. Inner HCal Integration/Installation
5. EMCal Integration/Installation
6. Tracking Integration/Installation

(Note: tooling, fixtures and procedures for the assembly of modules and sub-module components of the various detector subsystems, magnet related components are not covered in this item. See the WBS dictionary entries for those subsystems for that information)

WORK STATEMENT:

The tasks required for the integration, installation and assembly performed at PHENIX building 1008 are as follows:

1. CP Carriage Integration/Installation : Design analyses, drawings, procedures, procurement and fabrication of tooling for the assembly and installation of the CP carriage including base, roller supports, HCal cradle magnet mounting feet, platforms and access stairs.
   Deliverables: Drawings (estimated 3 assembly drawings 3 schematics), plans and work permits, custom tools and fixtures
2. sPHENIX SC Magnet Integration/Installation : Design analyses, drawings, procedures, procurement and fabrication of tooling for the installation and

integration of the sPHENIX SC magnet into the CP including cryo and electric integration, alignment/survey to CP, and full field test/commissioning of the magnet.

Deliverables: Drawings (estimated 1 assembly drawing, 3 schematics and 3 detail drawings), plans and work permits, custom tools and fixtures

3. Outer HCal Integration/Installation: Design analyses, drawings, procedures, procurement and fabrication of tooling for the installation/integration of the Outer HCal detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet.

   Deliverables: Drawings (estimated 1 schematic), plans and work permits, custom tools and fixtures

   Deliverables: Drawings (estimated 1 schematic), plans and work permits, custom tools and fixtures

4. Inner HCal Integration/Installation : Design analyses, drawings, procedures, procurement and fabrication of tooling for the installation/integration of the Inner HCal detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet.

   Deliverables: Drawings (estimated 1 schematic), plans and work permits, custom tools and fixtures

5. EMCal Integration/Installation : Design analyses, drawings, procedures, procurement and fabrication of tooling for the installation/integration of the Inner HCal detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet.

   Deliverables: Drawings (estimated 1 schematic), plans and work permits, custom tools and fixtures

6. Tracking Integration/Installation : Design analyses, drawings, procedures, procurement and fabrication of tooling for the installation/integration of the Tracking detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet.

   Deliverables: Drawings (estimated 1 schematic), plans and work permits, custom tools and fixtures

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03	sPHENIX Installation

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Summary Item - Rolls up costs from WBS Items 1.10.01 through 1.10.03

TECHNICAL CONTENT:

Includes assembly of Central Pedestal Carriage installation of Outer HCal, sPHENIX superconducting solenoid magnet, Inner HCal, EMCal, Tracker, Flux return end caps and all infrastructure and services to the detector subsystems and magnet. Also includes testing and commissioning of all detector subsystems as described in the subtasks, a full field test and full magnet mapping of the sPHENIX SC magnet with the Outer HCal (only) installed, and a final full field test and partial magnet mapping with all detector subsystems installed.

WORK STATEMENT:

See Subtasks

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/16/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03.01	Infrastructure Installation

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor and material costs for the Installation of the infrastructure items listed in the technical content below. All labor and material costs are based on engineering estimates

TECHNICAL CONTENT:

Installation and integration of the sPHENIX Infrastructure subsystems and subsystem upgrades (Line electric, cryogenics supply, beampipe/vacuum, IR HVAC, electronic cooling water, safety subsystems, detector support services, , detector access and non-IR infrastructure) with the sPHENIX detectors and support carriage.

WORK STATEMENT:

For each of the subsystems indicated carry out the indicated tasks to install/modify the subsystem components as follows:

1. Line Electric
    a. Main breakers
    b. lines to carriage sub-breakers
    c. distribution lines to lighting, outlets and rack power
2. Cryogenics support
    a. structural supports for Cryo transfer lines to carriage
    b. structural support for cryo lines on carriage

c. mounting and structural support for dewars

3. Beampipe/Vacuum
    a. Install temporary beampipe and beampipe supports for BES runs
    b. bakeout temporary beampipe
    c. Install beampipe supports and alignment adjustments
    d. Install central (beryllium/aluminum/stainless) beampipe, north and south 40 mm ID to 3-inch OD transition (stainless) beampipes, pumpout ports and isolation valves, north and south, bellows, north and south, 3 inch OD to 5inch OD transition (stainless) beampipes, and extension spool beampipes.
    e. bakeout all beampipe segments and activate neg coating
4. IR HVAC
    a. Install upgrades and replacement components
    b. Install monitoring lines and equipment
5. Electronics cooling water
    a. adapt existing supply and return to new primary distribution manifolds
    b. Install piping to carriage distribution manifolds
    c. Install carriage distribution manifolds
    d. connect to end users (e.g. rack fan tray heat exchangers)
    e. leak check all lines
6. Safety Subsystems
    a. Modify existing safety equipment
    b. Install new safety equipment
    c. test existing, modified and new equipment
7. Detector support services
    a. Install cable trays and cable tray support hardware
    b. Install all cables, fibers, monitoring and control lines
    c. Install dry air, and N2 lines and support hardware
    d. Install Racks (mechanical, connect electrical, plumbing and safety system equipment)
8. Detector Access
    a. Install rack platform access stairs and safety rails
    b. Install Bridge access ramp from permanent stair platforms to Central pedestal carriage.
9. non-IR infrastructure
    a. Install AH infrastructure modifications/upgrades
    b. Install Rack Room Upgrades and new DAQ equipment (see WBS 1.08 DAQ & Trigger)
    c. Install Control Room modifications/upgrades
    d. Install Gas Pad modifications/upgrades

Deliverable: None (Milestones for item completions and deliverables in WBS 1.09)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03.02	CP Carriage Assembly

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor and material costs for the Installation of the Central Pedestal Carriage and structural integration components items listed in the technical content below. All labor and material costs are based on engineering estimates

TECHNICAL CONTENT:

Assembly and installation of the CP carriage including base, roller supports, HCal cradle magnet mounting feet, platforms and access stairs.

WORK STATEMENT:

The tasks required to implement the assembly and installation of the CP carriage and structural Integration components are as follows:

1. Deliver the fabricated and purchased components of the base, roller supports, base alignment components, and HCal supports to the AH
2. Assemble item 1 components
3. (lower portion of Outer HCal installed as described in section 1.10.03.04)
4. Install magnet mounting and alignment provisions
5. (SC Magnet and remainder of Outer HCal installed as described in sections 1.10.03.03 and 1.10.03.04)

6. Install upper platform support columns and bracing and Flux return end caps.
7. (Magnet tests and mapping as described in WBS 1.03)
8. Remove Flux return end caps. Install Inner HCal Mounting supports
9. (other detector components installed as described in 1.10.03.05, 1.10.03.06, and 1.10.03.07
10. Install Flux return end caps

Deliverable: None (Milestones for item completions and deliverables in WBS 1.09.)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03.03	sPHENIX SC Magnet Installation

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor and material costs for the Installation of the sPHENIX Superconducting Solenoid Magnet and ancillary equipment as described in the technical content below. All labor and material costs are based on engineering estimates.

TECHNICAL CONTENT:

Installation and integration of the sPHENIX SC magnet into the CP including cryo and electric integration, alignment/survey to CP, and full field test/commissioning of the magnet.

WORK STATEMENT:

The steps required to undertake the assembly, installation and testing of the sPHENIX SC magnet are as follows:

1. (complete steps 1-4 for WBS item 1.10.03.02)
2. Using the AH crane, spreader bar and appropriate sling (note: spreader bar previously procured for the magnet under WBS 1.03) lift the magnet onto its mounting provisions described in 1.10.03.02 and align with survey
3. (Install remainder of Outer HCal and CP upper platform with supports and bracing as described in sections 1.10.03.03 and 1.10.03.04)

4. Install SC magnet Stack
5. Move CP carriage to IR for testing
6. (connect SC magnet cryo and electrical power for full field test and magnet mapping as described in WBS 1.03)
7. Move CP back to AH for additional assembly
8. Install additional detectors and infrastructure components as described in 1.10.03.02 steps 7 through 10.)
9. Move CP back to IR
10. (connect SC magnet cryo and electrical power for run conditions and perform full field commissioning tests as described in WBS 1.03)

Deliverable: None (Milestones for item completions and deliverables in WBS 1.03)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03.04	sPHENIX Outer HCal Installation

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description
COST CONTENT: Labor and material costs for the Installation of the Outer HCal Detector Subsystem as described in the technical content below. All labor and material costs are based on engineering estimates. TECHNICAL CONTENT: Installation/integration of the Outer HCal detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet. WORK STATEMENT: The steps required to install and align Outer HCal detector subsystem are as follows: 1. Transport fully assembled and tested (as described in 1.06.03) Outer HCal modules in groups of 4 modules to AH and place on temporary holding racks. Use custom Outer HCal module lifting fixture to load and unload modules onto transport truck. 2. Test to make sure electronics are intact after transport. 3. Install scaffolding at north and south ends of CP base.

4. Lift, orient and install first Outer HCal onto CP base HCal cradle matching up index features. Survey to align to base. Use custom outer HCal lifting fixture to lift, orient and position the module into place. Use custom aligning tools to achieve desired alignment
5. Install the next 3 modules, one at a time in a similar manner to the first module, alternating the installation between the east and the west.
6. Repeat steps 1 through 4 until 16 modules have been installed and aligned.
7. (Install the magnet as described in 1.10.03.03 steps 1 to 3)
8. Install custom temporary Upper HCal support/alignment fixture
9. Increase scaffolding for upper half of Outer HCal installation.
10. Repeat steps 1 through 4 until all 32 modules are installed
11. Test individual module electronics to assure that electronics have not been damaged during assembly
12. Install patch panels, cable management hardware, cable trays for Outer HCal .
13. Route Outer HCal cables and fibers to Outer HCal racks
14. Test all connections
15. Remove scaffolding.
16. (other detector subsystem installation and CP moved into IR as described in other 1.10.03 subsystem installation descriptions)
17. Commission testing for Outer HCal

Deliverable: None (Milestones for item completions and deliverables in WBS 1.06.03)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03.05	sPHENIX Inner HCal Installation

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor and material costs for the Installation of the Inner HCal Detector Subsystem as described in the technical content below. All labor and material costs are based on engineering estimates.

TECHNICAL CONTENT:

Installation/integration of the Inner HCal detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet.

WORK STATEMENT:

The steps required to install and align Inner HCal detector subsystem are as follows:

a. Transport all 64 fully assembled and tested (as described in 1.06.02) Inner HCal modules and place on temporary holding racks. Use custom EMCal module lifting fixture to load and unload modules onto transport truck.
b. Test to make sure electronics are intact after transport.
c. Assemble the EMCal indexed insertion tool on the south side of the

sPHENIX

d. One by one Insert and align the 32 south EMCal modules
e. Move the
f. Rotate the Installation fixture to move the installed Inner HCal module to the bottom position
g. Repeat steps 1 through 4 to install a Inner HCal module 2 positions away from the first module installed (leaving a single module gap)
h. Continue this way until 8 modules have been installed,
i. Transport an additional 8 modules to the AH
j. Install these 8 modules as before with single module gaps on either side of each module. At this point all of the temporary standoffs will have been removed.
k. Transport another 8 modules and install and align with adjacent modules, alternating between top and bottom to minimize variations in load distribution.
l. Transport the final 8 modules, install and align as before rotating the fixture each time to maintain load distribution as evenly as possible around the detector.
m. Make final alignment adjustments and secure end rings to lock all modules in place.
n. (Install Inner HCal support rings (see WBS item 1.10.03.02 item 8)
o. Install Inner HCal assembly installation I-beam and support, and attach to Inner HCal assembly fixture I-beam
p. Remove assembly fixture support on I-beam extension end.
q. Install the full Inner HCal, align and attach to the Inner HCal mounting supports.
r. Install patch panels, cable management hardware, cable trays for Inner HCal .
s. Route Inner HCal cables and fibers to Inner HCal racks
t. Test all connections
u. Remove scaffolding.
v. (other detector subsystem installation and CP moved into IR as described in 1.10.03.06 and 1.10.03.07 subsystem installation descriptions)
w. Commission testing for Inner HCal

Deliverable: None (Milestones for item completions and deliverables in WBS 1.06.02)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03.06	EMCal Installation

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor and material costs for the Installation of the EMCal Detector Subsystem as described in the technical content below. All labor and material costs are based on engineering estimates.

TECHNICAL CONTENT:

Installation/integration of the EMCal detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet.

WORK STATEMENT:

The steps required to install and align EMCal detector subsystem are as follows:

a. Transport all 64 fully assembled and tested (as described in 1.05) EMCal modules and place on temporary holding racks. Use custom EMCal module lifting fixture to load and unload modules onto transport truck.
b. Test to make sure electronics are intact after transport.
c. Assemble the EMCal indexed insertion tool on the south side of the sPHENIX structure

d. One by one insert and align the 32 south EMCal modules using the indexed insertion tool.
e. Move the EMCal indexed insertion tool to the north side of sPHENIX and reassemble
f. One by one insert and align the 32 north EMCal modules using the indexed insertion tool.
g. Make final alignment adjustments and secure and lock all modules in place.
h. Install patch panels, cable management hardware, cable trays for EMCal .
i. Route EMCal cables, fibers and services to EMCal racks or service distribution manifolds as appropriate
j. Test all connections
k. (Tracker detector subsystem installation and CP moved into IR as described in 1.10.03.07 and 1.10.03.03 subsystem installation descriptions)
l. Commission testing for EMCal

Deliverable: None (Milestones for item completions and deliverables in WBS 1.05)

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	01/15/2015	D. Lynch

4. WBS Element Code	5. WBS Element Title
1.10.03.07	Tracker Installation

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

10. Element Task Description

COST CONTENT:

Labor and material costs for the Installation of the Tracker Detector Subsystem as described in the technical content below. All labor and material costs are based on engineering estimates.

TECHNICAL CONTENT:

Installation/integration of the Tracking detector into the CP, power control and signal integration and commissioning of the detector, including alignment to the nominal beamline orbit and the magnet.

WORK STATEMENT:

The steps required to install and align Tracker detector subsystem are as follows:

a. Transport both fully assembled and tested (as described in 1.04) Tracker halves and place on temporary holding racks. Use custom Tracker half lifting fixture to transport halves to AH
b. Test to make sure electronics are intact after transport.
c. Assemble the Tracker support rails

d. Install both Tracker halves on the rail and align the halves to each other
e. Move the Tracker halves to its run position inside the magnet and other detectors
f. Make final alignment adjustments and secure and lock the Tracker in place.
g. Install patch panels, cable management hardware, cable trays for Tracker .
h. Route Tracker cables, fibers and services to Tracker racks or service distribution manifolds as appropriate
i. Test all connections
j. (CP moved into IR as described in 1.10.03.03 subsystem installation description)
k. Commission testing for Tracker

Deliverable: None (Milestones for item completions and deliverables in WBS 1.04)